

BLINDNESS AND VISUAL IMPAIRMENT AMONG PEOPLE WITH
DIABETES MELLITUS 40 YEARS AND OLDER IN THE LIMPOPO
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by

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DEDICATION

To the memory of my parents (David and Dorah Mabaso) and Reverend Idah Ntimane for their love, sacrifices, encouragement and for always reassuring me that everything will be all right.

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Above all, I would like to thank the Almighty God for giving me the strength and perseverance throughout the study period.

DECLARATION

I declare that **BLINDNESS AND VISUAL IMPAIRMENT AMONG PEOPLE WITH DIABETES MELLITUS 40 YEARS AND OLDER IN LIMPOPO PROVINCE, SOUTH AFRICA** is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references. This work has not been submitted before for any other degree at any other institution.

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ABSTRACT

The aim of this study was to determine the prevalence and causes as well as the risk factors of visual impairment (VI) and blindness among Black South Africans with diabetes mellitus (DM) aged 40 years and older in Mopani District, Limpopo province, South Africa.

This was a cross-sectional study in which Black South Africans with DM aged ≥ 40 years old were examined for VI and blindness. In addition, anthropometric as well as risk factors for VI and blindness were studied. A total of 225 participants were selected from seven Public Health Facilities in Mopani District. Data was collected using standard optometric instruments, anthropometric instruments and structured interviews. Data analysis was done using the Statistical Analysis System (SAS) and Microsoft Excel software packages.

The ages of the participants ranged from 40 to 90 years with a mean of 61.5 ± 10.49 years. There were more females (71.5%) than males (28.4%). The prevalence of uncorrected VI and blindness in the right eyes of the participants was 70.7% and 3.6%, respectively. In the left eyes, it was 72% and 3.1%, respectively. However, following optical correction, the prevalence in right eyes was 41.3% and 3.6%, respectively. In the left eyes, it was 42.2% and 3.1%, respectively.

Risk factors that were individually associated with VI and blindness include age, educational qualification, monthly income, knowledge of DM types, oral DM treatment (pills), losing weight, compliance to losing weight, family history of DM, physical activity, and date of last eye examination. When logistic regression was used, knowledge of DM types, pills, and compliance to losing weight, family history of DM, monthly income and physical activity remained associated with VI and blindness.

The high prevalence of VI in this diabetes population was not primarily due to DM itself, but due to refractive error and cataract,

conditions which have effective and easy treatments. A total of 84% of the participants were visually impaired due to either refractive error or cataract or both and only 3.8% due to diabetes retinopathy. It is therefore recommended that appropriate and affordable refraction and cataract surgical services be made available and accessible to this population.

Key terms: Blindness and visual impairment, diabetes, diabetic retinopathy, refractive error, visual acuity, cataract, prevalence and causes of visual impairment, clinical risk factors for visual impairment.

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CHAPTER 1

1.1 INTRODUCTION

Visual impairment or blindness is one of the most feared disabilities that a person can suffer. Persons with diabetes mellitus (DM) regard diabetic retinopathy and visual impairment as the most devastating complications of diabetes (Coyne, Margolis, Kennedy-Martin, Baker, Klein, Paul, Revicki 2004:450). This is probably because the affected persons are unable to perform simple tasks, such as reading, driving, walking around without assistance and independence generally.

The objective of this study was to determine the prevalence and causes of visual impairment among Black South Africans with DM who were 40 years and older in Mopani District of the Limpopo Province. Consequently, this chapter begins with an overview of visual impairment and blindness; the definitions, prevalence, factors influencing visual impairment and blindness as well as the consequences of visual impairment and blindness. Following this is an overview of DM wherein the definition, classifications, epidemiology and complications of diabetes are discussed. The background and source of the research problem, as well as the research problem are also outlined. The aim of the study, research questions, the significance of the study and the research design and method are outlined in this chapter.

1.2 AN OVERVIEW OF VISUAL IMPAIRMENT AND BLINDNESS

1.2.1 Definition of visual impairment and blindness

The World Health Organization (WHO) defines visual impairment (VI) as Presenting Visual Acuity (PVA) that is worse than 6/18, but better and equal to 3/60 or a corresponding Visual Field (VF) loss of $< 20^{\circ}$ around the central fixation in the better eye with presenting optical

correction if any (ICD-10, VI categories 1 and 2) (WHO 2011). Blindness is defined as PVA of worse than 3/60, or a corresponding VF loss of less than 10 degrees around the central fixation in the better eye with presenting optical correction if any (ICD-10, visual impairment categories 3, 4, and 5) (WHO 2011). In this study, the definition of visual impairment and blindness was adapted from the definition of visual impairment and blindness by the World Health organization (WHO 2011). The WHO revised categories of visual impairment (VI) is shown in Table 1.1

Table 1.1: Shows the revised categories of visual impairment

Presenting distance visual acuity		
Category	Worse than:	Equal to or better than:
Mild or no VI 0		6/18 3/10 (0.3) 20/70
Moderate VI 1	6/18 3/10 (0.3) 20/70	6/60 1/10 (0.1) 20/200
Severe VI 2	6/60 1/10 20/200	3/60 1/20 (0.05) 20/400
Blindness 3	3/60 1/20 (0.05) 20/400	1/60* 1/50 (0.02) 5/300 (20/1200)
Blindness 4	1/60* 1/50 (0.02) 5/300 (20/1200)	Light perception
Blindness 5	No light perception	
9	Undetermined or unspecified	

* Counts fingers (CF) at 1 metre

Adapted from: ICD update and revision platform: change the definition of blindness. From: <http://www.who.int/blindness/en/> (Accessed 13/10/2011).

According to the WHO (2008b), visual impairment is vision loss resulting from disease, trauma, or a congenital or degenerative condition that cannot be corrected by conventional means such as,

spectacles, contact lenses, medication, or surgery. Blindness is the inability to see (WHO 2011). However, this ultimate form of blindness is rare. The majority of “blind” people have a permanent loss of vision, but not all of their eyesight. The severity of vision loss can vary widely and may result in equally varying degrees of functional impairment (Prevent Blindness America 2002:4). The leading causes of blindness include eye disorders such as cataract, glaucoma, age-related macular degeneration, corneal opacities, and diabetic retinopathy, trachoma, etc (WHO 2011).

1.2.2 Prevalence of visual impairment and blindness

In 2010, the WHO released the new global estimates of visual impairment, which indicated that the number of people with presenting visual impairment was 285 million. Of these, 246 million had low vision and 39 million were blind. A larger percentage of people with visual impairment were over the age of 50 years (WHO 2012). In the African Continent, the WHO estimated the number of persons with visual impairment and blindness to be 26.3 million and 5.9 million, respectively (WHO 2012). However, the WHO cited that direct comparison of these estimates with earlier estimates of visual impairment and blindness is not possible due to differences in the methodologies used.

The first reliable data on visual impairment were published in 1990. In that report, the global estimate for the number of people with visual impairment was 148 million; 38 million were blind and 110 million had low vision. The global prevalence of blindness was 0.7% (Thylefors, Négrel, Pararajasegaram & Dadzie 1995:120). In the study conducted in 2002 (Resnikoff, Pascolini, Etya’ale, Kocur, Pararajasegaram, Pokharel & Mariotti 2004:848), the number of people with low vision and blindness was 124 million and 37 million, respectively. This indicated an increase of those with low vision from 110 million in 1990 to 124 million in 2002. However, the number of those with blindness decreased from 38 million to 37 million in the

same duration (Resnikoff *et al* 2004:848). The global estimate of the prevalence of blindness was 0.7% in 2000, and is expected to increase to over 1% by 2020, if appropriate interventions are not implemented to eliminate the causes of avoidable or preventable blindness. This increase is likely to result from the envisaged population growth and a rapid increase in the number of elderly people (Frick & Foster 2003:473). However, if VISION 2020 programmes are implemented successfully, the prevalence of blindness is expected to decrease to 0.3% by the year 2020 (Frick & Foster 2003: 474).

1.2.3 Factors influencing the visual impairment and blindness

The prevalence of visual impairment is expected to double by 2020, if measures to eliminate approximately 80% causes of avoidable blindness are not taken (Resnikoff & Pararajasegaram 2001:223). This implies that if health authorities and other stakeholders can identify the factors that influence the prevention of visual impairment and take appropriate action, then the prevalence of visual impairment can be reduced. Availability, accessibility, and affordability of eye care services have been identified as the three primary factors that could influence the prevention of visual impairment (Ntsoane & Oduntan 2010:183, Silva, Bateman & Contreras 2002:270). In addition, secondary factors such as demographic, personal and socio-economic factors have also been identified as barriers to the uptake of available, accessible, and affordable eye care services (Ntsoane & Oduntan 2010:183).

Eye care services are available in varying degrees in many countries of the world including in the developing countries. Within a country, availability of eye care services may vary from province to province, from district to district, from urban area to rural area and from one community to the other. In many developing countries, eye specialists are concentrated in major cities and towns, and thus excluding, for instance, the majority of rural people requiring

cataract surgery (Vaidyanathan, Limburg, Foster & Pandey 1999:104). This would result in an unnecessary increase in the prevalence of visual impairment. In some instances, services may be available, but not accessible to the potential beneficiaries. Accessibility is the travel time required by the public transportation to reach the nearest eye care provider (Silva *et al* 2002:271).

In some studies in the Caribbean and Central America, eye care services were considered as accessible if the travel time was <1.5 hours; marginally accessible if travel time was between 1.5 hours to 3 hours; inaccessible if travel time was >3 hours. Affordability of eye care services is based on the income levels, costs, efficiency and prices (Silva *et al* 2002:271). In the United States of America, a median-income worker may spend 3 days salary for an eye examination and a simple pair of prescribed reading glasses. In El Salvador, Trinidad and St. Vincent, the cost may be 15 days of salary; in Honduras it may be a month salary and so on (Silva *et al* 2002:271). This indicates that even in countries where eye care services are available, the prevalence of visual impairment would continue to increase as long as services are not accessible and affordable.

Availability, accessibility and affordability of eye care services are not the only factors that could influence the prevalence of visual impairment. Other factors that were identified as barriers to the uptake of eye care services include fear of doctors or hospital environment and fear of treatment. Limitation of daily activities after the operation, being told to wait for cataract to “mature”, and no one to accompany them to the eye clinic and cultural beliefs were also cited as barriers responsible for the low uptake of services (Fletcher, Donoghue, Devavaram, Thulasiraj, Scott, Abdalla, Shanmughan & Murugan 1999: 1397, Vaidyanathan *et al* 1999:106).

1.2.4 The consequences of visual impairment and blindness

Visual impairment and blindness have a negative impact on the socioeconomic life of an individual, and when the prevalence of visual impairment and blindness in communities is high, the consequences become a significant public health problem (West & Sommer 2001:224). Visual impairment and blindness are associated with a number of difficulties with Activities of Daily Living (ADL) tasks as well as dependence and progression of disabilities (West, Munoz, Rubin, Schein, Bandeen-Roche, Zeger, German, Fried & the SEE Project Team 1997:78).

The visually impaired and blind individuals face many barriers in their lives including poor access to information; poor access to public premises, services and environment as well as high levels of unemployment (Daye 2005) [details in chapter 3].

In the Blue Mountains Eye Study, in Australia, participants with visual impairment were less likely to be married, to have higher qualifications, to own a home or be currently employed than those without visual impairment (Chia, Wang, Rochtchina, Smith, Cumming & Mitchell 2004:72). Similar findings were reported in the Singapore Malay Eye Study (Chong, Lamoureux, Jenkins, Aung, Saw & Wong 2009:1644). In the Blue Mountains Eye Study, both correctable and non-correctable visual impairment were found to have a detrimental impact on the Health-Related Quality Of Life (HRQOL) of the affected individuals, although the impact of the non-correctable was greater than that of correctable visual impairment. Individuals with visual impairment were more likely to have a history of angina and stroke (Chia *et al* 2004:72).

The costs of lost productivity and of rehabilitation and education of the blind constitute a significant burden to the individual, the family and society [details of the costs of visual impairment and blindness are discussed in chapter 2].

Literature reports have indicated that diabetes mellitus is a major public health problem that is likely to turn into a global epidemic (International Diabetic Federation (IDF) 2003:7). Approximately 10% of people who have had DM for 15 years develop severe visual impairment and about 2% become blind (WHO 2008d). Diabetic retinopathy (DR) is one of the many complications of DM and the leading cause of new cases of blindness in many developed countries and is becoming a frequent cause of blindness in developing countries. The WHO has estimated that DR is responsible for approximately 4.8% of the worldwide blindness (WHO 2006:1). In South Africa, diabetic retinopathy is responsible for approximately 8% of blindness [South African Department of Health (SA DoH) 2002:12]. This study focussed on visual impairment and blindness among Black South Africans with DM who were 40 years and older in Mopani District, Limpopo Province. An overview of diabetes and its ocular complications is discussed below.

1.3 OVERVIEW OF DIABETES

1.3.1 Definition and description of diabetes

Diabetes mellitus is a chronic disease characterised by chronic hyperglycaemia that causes damage to many of the body's systems, in particular the blood vessels and nerves. The chronic hyperglycaemia results from an inherited and/or acquired deficiency in insulin secretion, insulin ineffectiveness or both (WHO 2008a).

Diabetes insipidus (DI) is a rare disease that is characterised by the inability of the kidneys to conserve water as they perform their function of filtering blood. This causes the affected individuals to pass large volume of diluted urine, which results in polydipsia and the need to drink more water. Individuals with DI may quickly become dehydrated when they do not drink enough water (NIDDK 2012).

1.3.2 Classification of diabetes mellitus

The WHO in co-operation with the National Data group (USA) (WHO 2002:5), classified DM based on aetiology into Type 1, Type 2, Gestational diabetes, and other specific types of diabetes.

The vast majority of people with DM fall under Type 1 and Type 2. A brief description of the types of DM follows hereunder.

1.3.2.1 Type 1 diabetes mellitus

Type 1 was previously called “Juvenile-onset” diabetes or Insulin Dependent Diabetes Mellitus (IDDM). It includes all those cases that are primarily due to the destruction of the pancreatic islet beta cells. If untreated, the pancreatic islet beta cell destruction may lead to ketoacidosis, coma and death. Type 1 may be subdivided into those cases that can be attributed to auto-immune processes, as well as those with beta cell destruction and are prone to ketoacidosis for which aetiology and pathogenesis is unknown (Type 1 idiopathic) (American Diabetes Association 2004: S6). The characteristic feature of type 1 attributable to autoimmune processes is the presence of anti-GAD, islet cell or insulin antibodies that identify the autoimmune processes responsible for pancreatic beta-cell destruction (Alberti & Zimmet 1998: 545).

Insulin is a hormone that is produced only by the pancreatic beta cells and is responsible for the regulation of blood glucose. The cause of type 1 DM is not well understood, but genetic and environmental factors have been implicated as risk factors that may trigger the autoimmune process that causes the destruction of the pancreatic beta cells (Centers for Disease Control and Prevention 2008). Viruses, such as rubella, coxsackie B and mumps are possible triggers for pancreatic beta cells destruction. Type 1 DM

accounts for 5% of those with DM. This type of DM predominantly affects children and adolescence, but can occur at any age (Centers for Disease Control and Prevention 2012). Patients with type 1 DM often complain of sudden increased thirst (polydipsia), increased hunger (polyphagia), and increase urination (polyuria). The affected individuals require insulin therapy for survival (American Diabetic Association 2004:S6, WHO 2002:6, WHO 2009).

1.3.2.2 Type 2 diabetes mellitus

Type 2 DM was previously called “Adult-onset” or Non-Insulin Dependent Diabetes Mellitus (NIDDM). This type results from insulin resistance, a disorder in which cells do not use insulin properly, and/or defects in insulin production. Type 2 accounts for 90-95% of all diagnosed cases of DM. It is more common among older people who are obese, have family history of DM, history of gestational DM, and are physically inactive. Certain race or ethnic groups (African Americans, Hispanic Americans, and Indian Americans etc.) are at greater risk of developing type 2 than others (Centers for Disease Control and Prevention 2008). Unlike type 1, where the symptoms are sudden, symptoms in type 2 are gradual. As a result, the disease may be recognised several years after onset, once complications have already arisen (American Diabetes Association 2004: S7). Many of the affected individuals can control their blood glucose through healthy diet, participating in physical activities, weight loss, and taking oral medication (Centers for Disease Control and Prevention 2008, WHO 2009).

1.3.2.3 Gestational diabetes mellitus

This is a form of glucose intolerance diagnosed in some women during pregnancy. It usually occurs in obese women who have a family history of DM. Women with gestational DM are 20 to 50% at risk of developing DM. This percentage is much higher than the prevalence of DM in the general population. Offspring born to

mothers with hyperglycaemia during pregnancy are more at risk of congenital anomalies than those born to mothers without hyperglycaemia during pregnancy. Approximately 90% of complicated pregnancies by diabetes are due to gestational diabetes (American Diabetes Association 2004:S9, Buchanan & Kjos 1999:1854, Centers for Disease Control and Prevention 2008)

1.3.2.4 Other specific types of diabetes mellitus

These types of DM result from specific conditions such as surgery, medications, malnutrition, infections, pancreatic disease and other illnesses. These types of DM account for 1 to 5% of all diagnosed cases of diabetes (Centers for Disease Control and Prevention 2008, Centers for Disease Control and Prevention 2011).

1.3.3 Epidemiology of diabetes mellitus

Diabetes mellitus is one of the most common non-communicable diseases globally and is emerging to be one of the most challenging epidemics of the 21 century. It is the fourth or fifth leading cause of death in most developed countries and has become an epidemic in many developing and newly industrialised nations (IDF 2006).

Globally, the number of adults aged 20-79 years old with DM is projected to increase from 366 million in 2011 to 552 million by 2030. The prevalence of DM in the same age group is expected to increase from 8.3% in 2011 to 9.9% by 2030. It is estimated that 80% of the 552 million people with DM live in developing countries (IDF 2011).

The WHO estimates that globally, approximately 2.9 million deaths per year are attributable to DM, and approximately 80% of the deaths occur in low and middle-income countries. Without immediate intervention, diabetes-related deaths will increase by more than 50% in the next decade (WHO 2009).

Before the 1950's, very few Africans suffered from diabetes. However, after the 1950's, the condition has now become a major public health problem and challenge throughout the continent. The regional prevalence of DM is projected to increase from 3.8% in 2011 to 4.3% in 2030; from 14.7 to 28 million persons with the disease (IDF 2011). The increase in the occurrence of DM among Africans is attributed to among other factors, ageing population, urbanisation, decreased physical activity, and replacement of traditional nutritious diets with western-style diets, which lead to an increase in the number of obese people (IDF 2006).

The crude prevalence of DM, impaired glucose tolerance (IGT), and impaired fasting glycaemia (IFG) in Greater Accra, Ghana, was 6.3%, 10.6% and 6.1%, respectively. Age standardisation to the Ghanaian population yielded a DM prevalence of 6.1%, 10.5% for IGT and 6.1% for IFG (Amoah, Owusu & Adje 2002:200). The crude prevalence rate of type 2 DM in Port Harcourt, Nigeria was 6.8%, and the standardised prevalence was 7.9% (Nyenwe, Odia, Ihekwaba, Ojule & Babatunde 2003:182). The national standardised prevalence rate of type 2 was 2.2%; while the crude prevalence was 7.4%, in those aged 45 years and above who live in urban areas (Nyenwe *et al* 2003:182).

In a study conducted in Kenya, the age-adjusted prevalence of DM was 4.2% among females and 4.5% among males. The age-adjusted prevalence was higher among urban dwellers (12.2%) than among rural dwellers (2.2%). The age-adjusted prevalence of impaired glucose tolerance (IGT) was 12%; with 13.1% among females and 6.1% among males. As with DM, the age-adjusted prevalence of IGT was higher among urban dwellers (13.2%) than among rural dwellers (8.6%) (Christensen, Friis, Mwaniki, Kilonzo, Tetens, Boit, Omondi, Kaduka & Borch-Johnsen 2009:306).

The prevalence of DM and impaired glucose tolerance in South Africa among Africans is 5% and among Indians is 11-13 % (SA DoH

2002: 12). In a study conducted in the Province of kwazulu Natal in South Africa, the crude prevalence of DM, IGT, and impaired fasting glycaemia (IFG) was 4.6%, 6.4%, and 1.6%, respectively. The age-adjusted prevalence was 3.9% for DM, 4.8% for IGT, and 1.5% for IFG. The prevalence was similar in both males and females for diabetes and IGT, whereas IFG was higher in males than females (Motala, Esterhuizen, Gouws, Pirie & Omar 2008:1785).

In South Africa, diabetic retinopathy is the third leading cause of blindness, after cataract and glaucoma. For planning purposes, diabetic retinopathy accounts for 8% of blindness, a figure that is on the increase (SA DoH 2002: 12). To prevent the increase in the prevalence of blindness due to DM, governments and health policy-makers should take appropriate steps to minimise the incidence of diabetes where possible.

1.3.4 Complications of diabetes mellitus

The major complications of DM include cardiovascular diseases, nephropathy, neuropathy, and retinopathy. About 70-80% of people with DM die of cardiovascular diseases; about 10% to 20% die of nephropathy. People with DM are 15 to 40 times more likely to require neuropathy-related lower limb amputation compared to the general population (IDF 2006). Only the ocular complications of DM will be discussed here.

1.3.4.1 Ocular complications of diabetes mellitus

Diabetic retinopathy is one of the most serious complications of DM. It is the number one cause of new cases of blindness among adults aged between 20-74 years old in developed countries (Centers for Disease Control and Prevention 2008). Diabetic retinopathy results from damage to the capillary walls of the blood vessels due to chronic hyperglycaemia. These micro-vascular changes in the retina lead to the weakening of capillary walls of the blood vessels

resulting in aneurysms formation. Because the walls of the micro aneurysms are weak and soft, they normally rupture resulting in retinal haemorrhage and scattering of lipids. This results in ischemia and micro-infarctions that may lead to loss of vision (Watkins 2003:924-925). The generalised retinal ischemia triggers the formation of new blood vessels (neovascularisation) which are prone to haemorrhaging, scar tissue formation and possible retinal detachment. This ischemic process can also trigger iris neo-vascularisation, which may result in neo-vascular glaucoma with consequent visual impairment or blindness (Watkins 2003:924-925).

The Early Treatment Diabetic Retinopathy Study group (ETDRS), classified diabetic retinopathy into Non-Proliferative Diabetic Retinopathy (NPDR) and Proliferative Diabetic Retinopathy (PDR) with a subcategory of diabetic macula oedema. The NPDR is characterised by micro-aneurysms, dot-blot haemorrhages, flame shaped haemorrhages, cotton-wool spots, intra-retinal micro-vascular abnormalities (IRMA), hard exudates, capillary and arteriolar occlusion. The PDR is characterised by neovascularisation of the disc (NVD) and neovascularisation elsewhere (NVE), neovascularisation of the iris (NVI), retinal detachment, and vitreous haemorrhages (Alexander 1994: 241, Singh, Ramasamy, Abraham & Gupta 2008).

The common cause of visual impairment in NPDR is clinically significant macula oedema. Clinically significant macula oedema is defined as one of the following: Retinal oedema within 500µm of the fovea, hard exudates within 500µm of the fovea if associated with adjacent retinal thickening and retinal oedema that is 1500µm or larger, any part of which is 1500µm of the fovea. About 20% of eyes with clinically significant macula oedema will have serious vision loss within 2 years if untreated, as compared to 8% of treated eyes. Severe vision loss in eyes with PDR may be due to tractional retinal detachment involving the macula, non-clearing vitreous haemorrhage, neo-vascular glaucoma, and macula oedema or

macula ischemia. Twenty six percent of the eyes with NVD will progress to severe vision loss within 2 years if untreated, as compared to 11% of treated eyes (Chalam *et al* 2005: 10, Watkins 2003: 924-925).

Although diabetic retinopathy is the major cause of vision loss in diabetic patients, it is, however, not the only cause of vision loss in these patients. Several non-retinal abnormalities may contribute to visual impairment or even blindness among people with DM. These conditions include corneal diseases, glaucoma, cataracts, optic nerve diseases, cranial nerve abnormalities, and infectious diseases. These conditions should also be considered in the management of patients with DM (Al-Till, Al-Bdour & Ajlouni 2005)

1.4 BACKGROUND INFORMATION ABOUT THE RESEARCH PROBLEM

1.4.1 Background and source of the research problem

Diabetes mellitus is one of the most common chronic age-related conditions worldwide. It is among the leading causes of death, disability, and economic loss throughout the world. In almost all developed nations, DM is among the leading causes of blindness and renal failure. There is substantial evidence that DM is an epidemic in many developing and industrialised nations (IDF 2003:1-13).

The WHO has estimated that the global prevalence of DM for all age groups was 2.8% in 2000 and is expected to increase to 4.4% by 2030. The number of people with DM is projected to increase from 171 million in 2000 to 366 million by 2030 (Wild, Roglic, Green, Sicree & King 2004:1047). The majority of the people with DM in developing and developed countries are in the age range of 45-64 years and >65 years, respectively (King, Aubert & Herman 1998: 1418, Wild *et al* 2004:1050). Since approximately 80% of people with

DM live in developing countries (IDF 2006), it follows that people with DM in developing countries will suffer more years with the condition than those in developed countries. Consequently, the incidence and prevalence of visual impairment and blindness will be higher in developing countries than in developed countries in the next decade or two.

More than 75% of the world's blindness is either preventable or treatable (Resnikoff *et al* 2001:224). In view of this, the WHO, in partnership with the International Agency for the Prevention of Blindness (IAPB) launched the "Vision 2020 – Right to Sight" initiative with the goal of eliminating avoidable blindness by the year 2020. This initiative targeted avoidable blindness due to cataract, refractive errors, trachoma, onchocerciasis, and other corneal scarring (WHO 2007:1).

Diabetic retinopathy was not included in the causes of avoidable blindness during the launch of "Vision 2020 – Right to Sight" initiative; but it is currently recognised as the number one cause of new cases of blindness among adults aged 20-74 years old in most developed countries, including the United States (Centers for Disease Control and Prevention 2008). The percentage of Americans who developed diabetic retinopathy was 25%, 60%, and 80%, within the first 5 years, after 10 years and after 15 years, respectively (Chalam, Lin, Mostafa 2005: 10). Among type 2 patients with DM of less than 5 years, 40% of those taking Insulin and 24% of those taking non-insulin treatments had diabetic retinopathy. After about 20 years, these rates increased to 84% and 53%, respectively (Chalam *et al* 2005: 10).

In North America, 3.6% of patients with type 1 DM and 1.6% of patients with type 2 DM are legally blind. In England and Wales, about 1000 patients are registered as blind or partially sighted each year, with diabetic retinopathy being the most common cause of blindness among economically active individuals (Watkins

2003:925). In the United States, diabetic retinopathy causes 12000 to 24000 new cases of blindness each year (Centers for Disease Control and Prevention 2008).

The researcher is concerned about increase in the prevalence of DM and the possible increase in the number of the visually impaired or blind diabetic adults in the Mopani District in Limpopo Province.

Many adults aged 40 years and older who visit optometry practices for eye examination have DM. There is no doubt that other health professionals also see more and more adults in the same age group with DM in their practices. In social functions, many adults choose sugar-free drinks, and when asked why they choose sugar-free drinks, they mention that they have DM. This suggests that the prevalence of DM is on the increase. Some of the people with DM are already visually impaired or blind due diabetic ocular complications. Many literature reports indicate that DM is the leading cause of new cases of blindness. Individuals with DM are more than twice more likely of becoming visually impaired or blind than those without DM (Ryskulova, Turczyn, Makuc, Cotch, Klein & Janiszewski 2008). This suggests that more people with DM will become visually impaired or blind if steps are not taken to prevent the incidence of DM and its ocular complications.

The researcher could not find literature reports on the data on visual impairment and blindness among people with DM in the Limpopo Province of South Africa. The lack of these data implies that people with DM and the population in general do not have adequate information about the serious impact of DM on vision. The researcher therefore felt that it was necessary to conduct this study to provide data on the prevalence, causes and associated risk factors of visual impairment and blindness among Black South Africans with diabetes in the Limpopo Province.

1.5 THE RESEARCH PROBLEM

According to Kumar (2005:20), a research problem is what tells the researcher, the research supervisor and the readers what the researcher wants to research. Welman, Kruger & Mitchell (2005:15) refer to a research problem as “some difficulty that the researcher experiences in the context of either a theoretical or practical situation and to which he wants to obtain a solution”.

Anecdotal evidence suggests that many adults, particularly those who are 40 years and older, who visit optometry practices for eye examination have DM. As mentioned above, the increased number of people with DM visiting health facilities for treatment indicates the need for prompt action to minimise the complications of this disease, particularly the ocular complications. Without prompt intervention, many adults with DM are at risk of becoming visual impaired or even blind due to DM ocular complications

The research problem in this study is the increase in the prevalence of DM more especially among adults, which may lead to visual impairment and blindness. The researcher was therefore interested in establishing the prevalence and causes as well as the risk factors of visual impairment or blindness among Black diabetic adults who were 40 years and older in Mopani District in the Limpopo Province.

1.6 AIM OF THE STUDY

The aim of this study was to determine the prevalence and causes as well as the risk factors of visual impairment and blindness among Black South African diabetic adults who are 40 years and older in Mopani District, Limpopo province.

1.6.1 Research questions

According to Kumar (2005:46), research questions are questions that researchers ask themselves about what they need to find out in a subarea of interest. This author further states that research questions are objectives that have been transformed into question form (Kumar 2005:46).

This study sought to determine the prevalence and causes of visual impairment and blindness among Black South Africans with DM aged 40 years and older in Mopani District, Limpopo Province. Visual impairment and blindness among people with DM may be due to various causes such as, uncorrected refractive error, cataracts, glaucoma, retinopathy etc. In addition, the study sought to determine the relationship between risk factors for visual impairment or blindness among people with DM.

Research questions in this study are:

- i. What is the prevalence of visual impairment or blindness among the Black South Africans with DM aged 40 years and older in Mopani District, Limpopo Province?
- ii. What are the causes of visual impairment or blindness among the Black South Africans with DM aged 40 years and older in Mopani district, Limpopo Province?
- iii. What are the risk factors that are associated with visual impairment or blindness among the Black South Africans with DM aged 40 years and older in Mopani District, Limpopo Province?

The objectives of this study are to:

- a. Determine the prevalence of visual impairment or blindness among the Black South Africans with DM aged 40 years and older in Mopani District, Limpopo Province.

- b. Determine the causes of visual impairment or blindness among the Black South Africans with DM aged 40 years and older in Mopani District, Limpopo Province.
- c. Describe the risk factors that are associated visual impairment or blindness among the Black South Africans with DM aged 40 years and older in Mopani District, Limpopo Province.

1.7 SIGNIFICANCE OF THE STUDY

Diabetes mellitus is a leading cause of new cases of visual impairment and blindness worldwide. Visual impairment and blindness due to DM is largely preventable through early detection, monitoring and management of diabetic eye diseases. This study would provide data on visual impairment and blindness among Black South Africans with DM 40 years and older to the Limpopo Province health authorities to assist in planning for eye care delivery in general, and among people with DM in particular. The findings from the study would assist the eye care practitioners to appreciate the extent of visual impairment and blindness due to DM among Black adults 40 years and older in Limpopo Province. The eye care practitioners would also appreciate the risk factors associated with visual impairment and blindness among people with DM in this age group, in this locality. The findings from the study would assist all the stakeholders in healthcare to plan for prevention of visual impairment and blindness due to diabetes.

1.8 RESEARCH DESIGN AND METHOD

According to Kumar, a research design is “a procedural plan that is adopted by the researcher to answer research questions validly, objectively, accurately and economically” (Kumar 2005:84). Mouton refers to a research design as a plan or a blueprint of how the researcher intends to conduct the research. A research design focuses on the final product; it gives an idea of the kind of study that is planned, the kind of results that are to be achieved, and the

kind of evidence that is required to answer the questions adequately (Mouton 2001: 55). The above definitions agree that a research design is a plan that the researcher needs to use to conduct a study that at the end will give answers to the research questions.

1.8.1 Study design

This was a health facility-based, quantitative, descriptive and a cross-sectional study in which Black South Africans with DM who were 40 years and older in the Limpopo Province were examined for visual impairment and blindness.

1.8.2 Research method

The study was conducted in seven health facilities, which included two hospitals, four clinics, and one health centre in Mopani District in the Limpopo Province. Convenience sampling was used to select participants for this study. The researcher used three forms of data collection instruments. The first form included standard optometric instruments used for vision screening and eye examination to determine the presence or absence of visual impairment. The instruments included the logMAR visual acuity chart (Landolt "C"), Auto-refractor, pinhole and an ophthalmoscope. The second form included instruments used to take anthropometric measurements (height and weight). These included a tape measure and a bathroom scale and the third form of data collection instruments was structured interviews wherein participants were asked questions on their socio-demographic characteristics, clinical characteristics of DM, knowledge of DM and its ocular complications, family history, hypertension, smoking habits as well as accessibility to health facilities. The research design and methodology used in this study are presented in detail in Chapter 4

1.9 CONCLUSION

This chapter began with an overview of visual impairment and blindness; the definitions, prevalence, factors influencing visual impairment and blindness as well as the consequences of visual impairment and blindness were discussed. Following this was an overview of DM wherein the definition, classification, epidemiology and complications of DM were discussed. The background, source and statement of the research problem, as well as the research problem were also outlined. The aim of the study, research questions, the significance of the study and the research design and method were outlined in this first chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The preceding chapter provided background information to the present study. It provided an overview of visual impairment and blindness as well as an overview of DM. An outline of the background and source of the research problem, the statement of the problem and the research problem was presented in the preceding chapter. The aim, research questions, the significance of the study as well as the research design and method were also outlined in chapter 1.

This chapter begins with a historical overview of visual impairment and blindness. The historical overview is examined under the following headings: the global prevalence of visual impairment and blindness, the causes of visual impairment and blindness, and the distribution of visual impairment and blindness. An outline of the distribution of visual impairment and blindness by age and gender and geographical regions as well as the cost of visual impairment and blindness is presented in this chapter. A historical overview of the prevention of visual impairment and blindness is also discussed in this chapter.

Since the present study focuses on diabetes-related visual impairment and blindness, it is important that an overview of DM is discussed. The definition of DM, the new classification of DM, which includes clinical stages of DM and other categories of glucose tolerance and aetiological classification of DM are discussed. The epidemiology of DM; two studies that provide reliable estimates on the prevalence of DM and the projections by 2025 and 2030 are discussed to highlight the public health importance of DM. Under diabetic retinopathy (DR), the clinical features of non-proliferative

diabetic retinopathy, proliferative diabetic retinopathy, and diabetic maculopathy are also described. The various classifications of DR are described and tabulated. A discussion of the historical overview of the diabetic retinopathy studies, which includes the Wisconsin Epidemiological Study of Diabetic Retinopathy (WESDR), the Diabetes Control and Complications Trial (DCCT), the United Kingdom Prospective Diabetes Study (UKPDS) and the Early Treatment of Diabetic Retinopathy Study (ETDRS). A review of diabetic retinopathy studies, the prevalence and incidence of visual impairment and blindness, the risk factors for diabetic retinopathy, visual impairment and blindness and the causes of visual impairment and blindness is also discussed in this chapter.

2.2 HISTORICAL OVERVIEW OF VISUAL IMPAIRMENT AND BLINDNESS

As early as 1978, the World Health Organization Programme for the Prevention of Blindness (WHO/PBL) was established, and its priority was to find detailed information on the prevalence, distribution and causes of blindness worldwide (Thylefors *et al* 1995:115). In addition, the WHO/PBL was expected to assist WHO Member States to organise programmes and activities aimed at preventing and controlling blindness due to four major causes namely, trachoma, onchocerciasis, xerophthalmia and cataract (Resnikoff & Pararajasegaram 2001:223). Some of these conditions were later identified as priority eye diseases in the VISION 2020 initiative that was launched in 1999 to eliminate causes of preventable blindness by 2020.

2.2.1 The global prevalence of visual impairment and blindness

The global prevalence of blindness is expected to increase from 0.7% in the year 2000 (44 million blind people) to over 1% (76 million blind people) by 2020, if appropriate interventions are not implemented to eliminate the causes of avoidable or preventable

blindness. However, if VISION 2020 programmes are implemented successfully, the prevalence of blindness is expected to decrease to 0.3% (24 million blind people) by the year 2020 (Frick & Foster 2003: 474).

Data on the prevalence, distribution and causes of visual impairment and blindness are required in order to establish sustainable programmes for the prevention of these conditions. The first reliable estimate using WHO standardized guidelines and protocols for collecting data on the prevalence and causes of visual impairment was published in 1990. The global estimate for the number of people with visual impairment was 148 million; 38 million people were blind and 110 million had low vision. The global prevalence of blindness was 0.7% (Thylefors *et al* 1995:120).

The second global estimates of visual impairment were done in 2002. The number of blind people and the prevalence of blindness were 37 million and 0.6%, respectively; these were slightly lower than the 1990 estimates (Resnikoff *et al* 2004:848). The differences between the 1990 and 2002 estimates might be because the blindness prevention programmes have succeeded in eliminating some causes of avoidable blindness. The other explanation for the differences might be that there has been an overestimation in the 1990 projections or an underestimation in the 2002 projections. The number of those with low vision was higher (124 million) than the 1990 estimate (110 million). An increase in the number of the elderly (≥ 60 years) in the past decades is the likely explanation for the increase in the prevalence of low vision that is due to both avoidable and unavoidable causes (Resnikoff *et al* 2004:848).

2.2.2 The causes of visual impairment and blindness

Over the past two decades, societal changes and improvements in medical technology have resulted in corresponding changes in the causes of visual impairment and blindness. Diabetic retinopathy and

age-related macular degeneration have risen in statistics as major causes of visual impairment ; while infectious causes of blindness, such as trachoma, onchocerciasis, and xerophthalmia have decreased in statistics (West & Sommer 2001:245).

In the 1990 global estimate of visual impairment, the major causes of blindness were cataract (41.8%), trachoma (15.5%), glaucoma (13.5%), onchocerciasis (0.9%), and all the others (28.3%) (Thylefors *et al* 1995: 118). In the 2002 global estimates of visual impairment, the leading causes of blindness were cataract (47.8%), glaucoma (12.3%), age-related macular degeneration (8.7%), diabetic retinopathy (4.8%), trachoma (3.6%), onchocerciasis (0.8%) and others (22%) (Resnikoff *et al* 2004:848).

Between 1990 and 2002, blindness due to trachoma and onchocerciasis decreased from 15.5% to 3.6% and 0.9% to 0.8%, respectively (Resnikoff *et al* 2004:848). This might be an indication of the successes of the blindness prevention programmes that were established to eliminate these infectious causes of blindness. Age-related macular degeneration and diabetic retinopathy (which were insignificant causes of blindness in 1990) have, in 2002 emerged to be the third and fourth leading causes of blindness, respectively (Resnikoff *et al* 2004: 848). This indicates that there has been an increase in the number of people who are blind due to age-related conditions, and a decrease in blindness due to infectious diseases.

The 2002 global estimates indicate that cataract was still the leading cause of preventable blindness and has even become a more significant cause of low vision and blindness than in the 1990 estimates. This may be the result of an increase in the population of the 60 years and older (who are the most affected by cataracts) between 1990 and 2002. Although cataract is responsible for almost half of all blindness worldwide, it is no longer a major cause of blindness in developed countries. However, this condition is still a major cause of low vision and blindness in low- and middle-income

countries. This is because many people in these countries cannot afford cataract surgery due to their destitution, lack of education, inadequate health services, etc (Resnikoff *et al* 2004: 849).

2.2.3 The distribution of visual impairment and blindness

2.2.3.1 The distribution of visual impairment and blindness by age and gender

Visual impairment tends to increase with increasing age. This is because most causes of visual impairment are age-related. Conditions such as cataract, glaucoma, diabetic retinopathy, and age-related macular degeneration are age-related eye conditions, and have since become significant causes of visual impairment. Globally, females have been reported as having a significantly higher risk of visual impairment than males (Resnikoff *et al* 2004:847, WHO 2010). This can be accounted for by females longevity, higher rates of some diseases with ophthalmological complications in females, inaccessibility of health care, which is preferentially made accessible to males than females in some societies and behavioural and environmental factors (Shahriari, Izadi, Rouhani, Ghasemdadeh & Maleki 2007:583).

2.2.3.2 The distribution of visual impairment and blindness by geographical regions

Visual impairment is not uniformly distributed throughout the various regions of the world. In the developed countries, the number of blind people increased from 3.5 million in 1990 to 3.8 million in 2002. Whereas, in the developing countries, excluding China and India, the number of blind people increased from 18.8 million in 1990 to 19.4 million in 2002. Approximately 87% of the visually impaired live in the developing countries , which indicates a need for resources to be directed to these countries if the global burden of visual impairment is to be reduced (Resnikoff *et al* 2004:848, WHO 2010).

In sub-Saharan Africa, the number of blind people is estimated at 9 million and those with low vision at 27 million. The number of blind people in this region is estimated to increase to 15 million by 2020. Cataract is responsible for 50% of blindness and is still the leading cause of blindness in sub-Saharan Africa (WHO 2009).

2.2.3.3 The cost of global visual impairment and blindness

The annual loss of economic productivity due to blindness is projected to increase from \$19 billion in the year 2000 to \$50 billion by the year 2020. In addition, when blindness and low vision are combined, these figures will increase from \$42 billion to \$110 billion, in the years 2000 and 2020, respectively, if VISION 2020 programmes are not implemented. However, these figures will increase from \$19 billion to \$26 billion (for blindness) and from \$42 billion to \$57 billion (for blindness and low vision), if VISION 2020 programmes are successfully implemented (Frick & Foster 2003: 474).

In sub-Saharan Africa alone, the annual loss in economic productivity due to blindness is projected to increase from \$838 million in the year 2000 to \$2 billion in the year 2020, if VISION 2020 programmes are not implemented. If VISION 2020 programmes are successfully implemented, these figures will decrease from \$838 million to \$514 million, in the year 2000 and 2020, respectively (Frick & Foster 2003: 474). It is evident from these figures that implementation of VISION 2020 programmes will lead to considerable savings in healthcare and social expenditures. This would result from the fact that fewer people will rely on government for medical or social assistance emanating from visual impairment. These savings would therefore assist health departments in directing resources to diseases that are unavoidable.

2.2.4 Historical overview of the prevention of visual impairment and blindness

As early as the 1950's, the World health Organization (WHO) has been in the forefront of assisting Member States to address the challenge of those becoming blind from preventable causes. At the time, trachoma was recognized as the major cause of preventable blindness, and this led the WHO to establish a programme for the prevention of blindness due to trachoma (Third World Health Assembly, resolution WHA3.22 1973:98). The programme managed to reduce the prevalence of blindness due to trachoma, although it did not succeed in eradicating the condition completely.

The World Health Organization/PBL collaborated with the International Agency for the Prevention of Blindness (IAPB) to initiate national programmes for the prevention of blindness within the WHO Member States. Because of this collaboration, over 50 national programmes were established by the mid-1980's and by 1998 the number had increased to 110 (Resnikoff & Pararajasegaram 2001:223). In 1999, WHO/PBL together with the IAPB and professional bodies, international governmental and non-governmental organizations launched the VISION 2020 - The Right to Sight initiative. The goal of this initiative has been to eliminate preventable or avoidable blindness by the year 2020. The causes of blindness that were prioritized for VISION 2020 initiative were cataract, trachoma, onchocerciasis, avoidable causes of childhood blindness, uncorrected refractive errors and low vision. These five causes were responsible for approximately 75% of all blindness globally (Resnikoff & Pararajasegaram 2001: 224).

Since the establishment of WHO/PBL in 1978 and VISION 2020 initiative in 1999, the numbers of people becoming blind due to trachoma, onchocerciasis and vitamin A deficiency have decreased. This has happened probably due to an improvement in socioeconomic development and medical technology in the past two

decades. Many countries have access to clean running water, sanitation, better nutrition and certain necessary therapeutic medicines (Foster, Gilbert & Johnson 2008:37).

Despite these achievements by many countries, the number of visually impaired individuals is projected to double by the year 2020. This increase is likely to result from the projected population growth and a rapid increase in the number of elderly people (Frick *et al* 2003:473). An increase in the number of the elderly suggests that there will be an increase in the number of blinding age-related eye diseases, such as diabetic retinopathy, glaucoma and age-related macular degeneration (Resnikoff & Pararajasegaram 2001:224). Countries where the priority eye diseases included in the VISION 2020 initiative are no longer the major causes of visual impairment have been advised to include these age-related eye diseases, as some of them have become serious public health problems (Resnikoff & Pararajasegaram 2001:224). Diabetic retinopathy for instance, is the leading cause of new cases of blindness among adults of working age in developed countries, and is gradually becoming a significant cause of blindness in urban areas of many developing countries (Thylefors *et al* 1995:115).

Visual impairment is undoubtedly a significant public health problem in the world. The sad fact is that visual impairment is likely to double in the next decade or two, if steps are not taken to eliminate the causes of avoidable / preventable blindness and low vision. Another disturbing reality is that the larger percentage of the increase in visual impairment will occur in developing countries where resources to deal with this problem are scarce. It is therefore recommended that the donor communities should seriously consider assisting the poor countries in implementing the VISION 2020 initiatives to fight the scourge of unnecessary visual impairment and blindness.

The present study will focus on visual impairment and blindness that is related to DM among Black South African people with diabetes in Mopani District, Limpopo Province. Diabetes is the number one cause of new cases of blindness among adults of working age in developed countries, and is gradually becoming a significant cause of blindness in the urban areas of developing countries (Alexander 1994:234, International diabetes federation 2006).

2.3 AN OVERVIEW OF DIABETES MELLITUS

An overview of DM has been presented in Chapter 1. The discussion below includes some details on areas that were covered in Chapter 1 and areas that were not tackled at all in the previous chapter.

2.3.1 Definition of diabetes mellitus

According to Alexander (1994:232), DM is a disease of improper glucose production and use, which may result from absence of insulin, reduced supplies of insulin, or inability or reduced ability for receptor sites to use insulin. Kanski (2003:691) defines DM as a common metabolic disorder characterized by sustained hyperglycaemia of varying severity secondary to lack, diminished efficacy, or both of endogenous insulin. The two definitions agree that DM may result from defects in insulin secretion, insulin action or both. However, the researcher feels that the definition by Alexander is inadequate, as it does not mention anything about sustained or chronic hyperglycaemia, which is undoubtedly an important characteristic feature in DM.

The defects in insulin action on target tissues lead to disturbances in carbohydrates, fat and protein metabolism. The long-term effects of DM include progressive development of diabetic retinopathy that may lead to blindness, Nephropathy that may lead to renal failure, neuropathy that may lead to foot ulcers and amputations. People

with DM are at increased risk of cardiovascular and cerebrovascular disease (WHO 1999: 3).

2.3.2 Classification of diabetes mellitus

The WHO and the American Diabetes association (ADA) expert committee on diagnosis and classification of diabetes published a new classification system of diabetes based on aetiology and clinical staging. An increase in the knowledge of the aetiology and pathogenesis of diabetes necessitated the changes in the classification of DM. According to the new classification, DM will no longer be classified based on whether the patients are dependent on insulin or not. Consequently, the terms “insulin dependent diabetes mellitus” and “non-insulin dependent diabetes mellitus” and their acronyms “IDDM” and “NIDDM” have been abandoned; and type 1 and type 2 DM have been retained as the two principal types of DM (Alexander 1994: 234, Alberti & Zimmet 1998: 543). The clinical stages of DM include normal glucose tolerance, Impaired Glucose Tolerance (IGT), Impaired Fasting Glycaemia (IFG), not insulin requiring, and insulin requiring. The aetiological types include type 1, type 2 DM and other specific types of DM (Alberti & Zimmet 1998: 544).

2.3.2.1 Clinical stages of diabetes mellitus and other categories of glucose tolerance

The clinical staging indicates that DM, regardless of its aetiology, progresses through several clinical stages during its natural history. In addition, individuals with DM may move from one clinical stage to another in either direction, depending on the extent of the underlying disease processes. Persons who have DM or are developing DM can be categorised by stage according to the clinical characteristics, even if the underlying aetiology is not known (Alberti & Zimmet 1998: 539, WHO 1999: 16).

a) Impaired Glucose Tolerance and Impaired Fasting Glycaemia

Impaired glucose regulation [Impaired Glucose Tolerance (IGT) and Impaired Fasting Glycaemia (IFG)] refers to a metabolic state intermediate between normal glucose homeostasis and DM. However, an emphasis is made to the fact that IGT and IFG are not the same concepts and should never be used interchangeably (WHO 1999: 14). The IFG refers to fasting blood glucose (FBG) concentrations that are lower than those required for diagnosis of DM, but higher than what is considered normal fasting glucose concentrations (WHO 1999:15). Therefore, patients having FBG levels of 6.1 to 6.9mmol/l are now defined as having impaired fasting glycaemia (IFG). On the other hand, IGT refers to blood glucose concentrations of 7.8 to 11.0 mmol/l 2 hours post 75g oral glucose load (i.e. oral glucose tolerance test) (WHO 1999:15).

In the new classification system, the values of the fasting blood glucose or IFG and the IGT have been lowered from ≥ 7.8 mmol/l to 6.1 to 6.9mmol/l, and from > 11.1 mmol/l to 7.8 to 11mmol/l, for IFG and IGT, respectively. The reasons for lowering these values were to improve the recognition of persons with undiagnosed DM, without increased risk of false-positive diagnosis. Secondly, it would make it possible to realise that the risk of diabetic retinopathy occurs at a lower FBG than was previously thought. It has to be noted that the changes would not increase the number of people with DM, but would increase the number of people with known DM (WHO 1999: 16).

b) Diabetes mellitus not requiring insulin for survival

This type of DM consists of two sub-divisions: the first is where insulin is required for metabolic control of hyperglycaemia rather than for survival. In this case, there is endogenous secretion of insulin, which is, however, not enough to achieve normal plasma

glucose without exogenous insulin. The second subdivision is where hyperglycaemia can be controlled by other methods such as exercises, diet, losing weight etc. and/or by drugs other than insulin. Altogether, these two sub-divisions were formerly called the Non Insulin Dependent Diabetes Mellitus (NIDDM) (WHO 1999:14). Referring to this type as NIDDM is misleading, as it is mentioned above, the patients in the first sub-division do depend on insulin though not for survival, as is the case with those in the “insulin requiring for survival” group.

c) Diabetes mellitus requiring insulin for the survival

This corresponds to what was previously called Insulin Dependent Diabetes Mellitus (IDDM). The patients with this type of DM require exogenous insulin for survival.

2.3.2.2 The aetiological classification of diabetes mellitus

The aetiological types of DM include type 1 and type 2 DM, other specific types, and gestational diabetes. A detailed description of these types has been presented in Chapter 1.

2.3.3 Epidemiology of diabetes mellitus

The prevalence of DM in the world is on the increase. In 1985, 30 million people worldwide had DM; by the year 2000, the figure had already risen to approximately 150 million (IDF 2009). In 2007, the prevalence of DM in adults aged 20-79 years in all the International Diabetes Federation (IDF) member countries (which are over 160 in number) was estimated at 6% (IDF 2006). In the same year, the number of people with DM in the same countries was estimated at 246 million and is projected to increase to 380 million by 2025. In 2008, the WHO estimated that there were 180 million people with DM worldwide (WHO 2009). Both the IDF and WHO estimates indicate

that the prevalence of DM and the number of people with DM is increasing at an alarming rate.

King *et al* (1998:1416) conducted a study to estimate the prevalence of DM, the number of people with DM in 1995 and the projections by 2025. In 1995, the global prevalence of DM was estimated at 4% and to increase to 5.4% by 2025. In addition, the number of people with DM was estimated at 135 million and to increase to 300million by 2025 (King *et al* 1998:1416). Wild *et al* (2004:1051) reported on the global prevalence and numerical estimates of DM in the year 2000 and their projections by the year 2030. In that report, the global prevalence of DM is expected to increase from 2.8% in the year 2000 to 4.4% by the year 2030. It was also reported that the number of people with DM will almost double between 2000 and 2030.

These two major studies agree that the number of people with DM will double in the next decade or two. The projected increase in the prevalence of DM will occur because of population ageing, unhealthy diet, overweight, obesity, and sedentary lifestyles (Wild *et al* 2004: 1047). This indicates that if people can be encouraged to revert to traditional lifestyles and dietary patterns, the increase in the prevalence DM can be minimised. There is growing evidence that changes in diet, physical activity or pharmacological treatment may reduce the prevalence of DM (Wild *et al* 2004: 1051).

The projected doubling of the number of people with DM worldwide between 2000 and 2030 suggests that the number of people with visual impairment will also double in the same period, if appropriate steps are not taken to prevent diabetes-related visual impairment. Approximately 75% of people with DM will live in developing countries by the year 2025 (King *et al* 1998: 1416). This can be explained by the higher projected increase in the number of adults in developing countries (47%), compared with the increase in developed countries (27%), between the year 1995 and 2025 (King

et al 1998: 1416) . The greatest relative increases in DM will occur in the Middle Eastern Crescent, India, and sub-Saharan Africa.

South Africa is a developing country in the sub-Saharan African region. In this region, the number of people with DM is expected to increase from 14.7 million in 2011 to 28 million by 2030 (IDF 2011). The number of South Africans (20-79 years) with DM in 2011 is estimated at 1.9 million, with at least 78% of the people with DM being undiagnosed (IDF 2011). Between 2009 and 2010, 301365 people visited Public Health Facilities in the Limpopo Province for DM treatment. Of this number, 49513 people visited facilities in the Mopani District during the same period (Limpopo Department of Health, Head Office 2011). These figures are undoubtedly an underestimation since there are people who use Private Health Facilities for their DM treatment.

The previous estimates of the number of people with DM in South Africa were much lower than the above estimates. The number of people with DM was expected to increase from 298000 in 1995 to 721000 by 2025 (King *et al* 1998: 1430). These statistics indicate that the number of South Africans with DM is increasing at a faster rate than previously expected. The increase in the number of persons with DM in South Africa, suggests that more persons are likely to be visually impaired due to DM related conditions, such as diabetic retinopathy, cataracts, glaucoma, macula oedema.

The aim of this study is to determine the prevalence and causes of visual impairment and blindness in persons with DM in Limpopo Province. According to Alexander (1994: 239-240), vision loss among people with DM is due to the following:

- (1) Macular oedema that results from leaking micro-aneurysms and intra-retinal vessels within the macula area.

(2) Vitreous haemorrhages that result from rupture of the neo-vascular nets that developed due to hypoxia or

(3) Retinal detachment that results from fibrosis proliferation.

2.3.4 Diabetic Retinopathy

Diabetic retinopathy is the major ocular complication of DM, and is rated as the number one cause of new cases of legal blindness among adults between the ages of 20 and 65 years. This condition is more common in persons with type 1 (40%) than those with type 2 (20%) diabetes mellitus (Kanski 2003: 439).

Kanski (2003:439) defines diabetic retinopathy as a micro-angiopathy affecting the pre-capillary arterioles, capillaries and post-capillary venules of the retina. On the other hand, Alexander (1994:238) defines diabetic retinopathy as a condition that occurs secondary to changes in the capillary wall structure of the retina leading to development of micro-aneurysms, vascular loops, and dilated capillaries allowing for the development of leakage. Hyperglycaemia and hypoxia are thought to be the cause of vascular changes, particularly vascular dilatation.

Diabetic retinopathy is the major cause of blindness among persons with DM (Henricsson, Tyrberg, Heijl, Janzon, 1996:535, Kumar, Goyder, McKibbin, 2006:456). It is therefore important for eye healthcare providers to be able to identify the various retinal lesions that characterize diabetic retinopathy, and how such lesions may lead to visual loss. A brief description of the clinical features of DR follows below:

2.3.4.1 Clinical features of Non-Proliferative Diabetic Retinopathy

a) Micro-aneurysms

Micro-aneurysms are found in the inner nuclear layer of the retina and are the earliest detectable signs of diabetic retinopathy. They appear as small red dots usually temporal to the fovea (Kanski 2003:441). Micro aneurysms occur due to hypoxia and are prone to leakage, creating oedema; should the oedema spread into the macula, visual acuity may be compromised (Alexander 1994: 241, Watkins 2003:924) (See Figure 2.1).

b) Nerve fibre layer or flame-shaped haemorrhages

These haemorrhages are located in the nerve fibre layer within the posterior pole and follow the course of the retinal nerve fibre layer. They represent a localized area of hypoxia (Kanski 2003:346). Flame-shaped haemorrhages have an irregular shape and are slightly larger than micro-aneurysms (Tarr *et al* 2011) (See Figure 2.1).

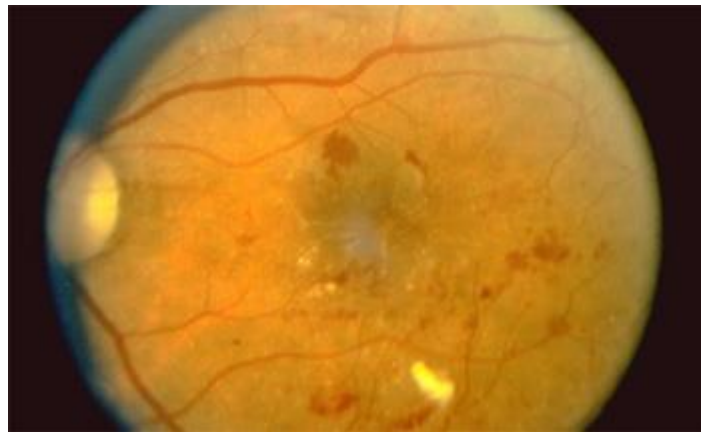
c) Intra-retinal or dot-blot haemorrhages

These haemorrhages represent ruptures in the weakened capillary walls. They indicate the presence of venous stasis and retinal oedema. If they are located in the macular area, vision may be threatened (Alexander 1994:241) (See Figure 2.1).

d) Retinal oedema

Retinal oedema is initially located in the outer plexiform and inner layers of the retina, later the inner nuclear layer and nerve fibre layer are involved and eventually the entire retinal thickness

becomes oedematous (Kanski 2003:442). When the macula oedema involves the centre of the fovea it is referred to as Clinically Significant Macular Oedema (CSMO). About 20% of the eyes with CSMO will have serious vision loss within 2 years without treatment compared with 8% of treated eyes (Watkins 2003:924). According to Paulus & Gariano (2009:19), the CSMO is normally associated with mild or moderate vision loss (between 20/20 to 20/200) but occasionally legal blindness (<20/200) occurs (Paulus *et al* 2009:19) (See Figure 2.1).



From: <http://www.southcoasteye.com/whatsnew.html>.

Figure 2.1: NPDR with micro-aneurysms, dot & blot haemorrhages (red), exudates (yellow), and macular oedema (clear wrinkles at centre of photo).

e) Hard exudates

Hard exudates are located with the outer plexiform layer of the retina (Kanski 2003:442). They are yellow-white intra-retinal deposits that result from abnormal leakage of serum proteins, lipids and fibrin from damaged capillaries and micro-aneurysms (Tarr, Kaul, Kohner, Chibber 2011). Hard exudates are arranged in a circular pattern and often surround a leaking blood vessel or micro-aneurysm (Kanski 2003: 442, Watkins 2003:924) (See Figure 2.2).



From: <http://www.aao.org/theeyeshaveit/optic-fundus/hardexudates.cfm>

Figure 2.2: Shows hard exudates arranged in a circular pattern around the microanerysm.

f) Cotton wool spots

Cotton wool spots are caused by occlusion of arterioles leading to interrupted axoplasmic transport and accumulation of axoplasmic debris (Kanski 2003: 443, Tarr *et al* 2011). They appear as small, whitish fluffy superficial lesions, which represent focal micro-infarcts of the retinal nerve fibre layer (NFL). Cotton wool spots obscure the underlying blood vessels and are located in the post-equatorial area of the retina where the NFL thickness is sufficient (Kanski 2003:443). They become clinically significant when they are more than five (Watkins 2003:924) (See Figure 2.3).



From: <http://bjo.bmj.com/content/current>

Figure 2.3: Shows a retinal cotton wool spot. The unusually large white lesion (left) appears to be “isolated” at first glance. It masks the fluorescence of the underlying choroid on fundus fluorescein angiography (right), as well as showing venular dye leakage.

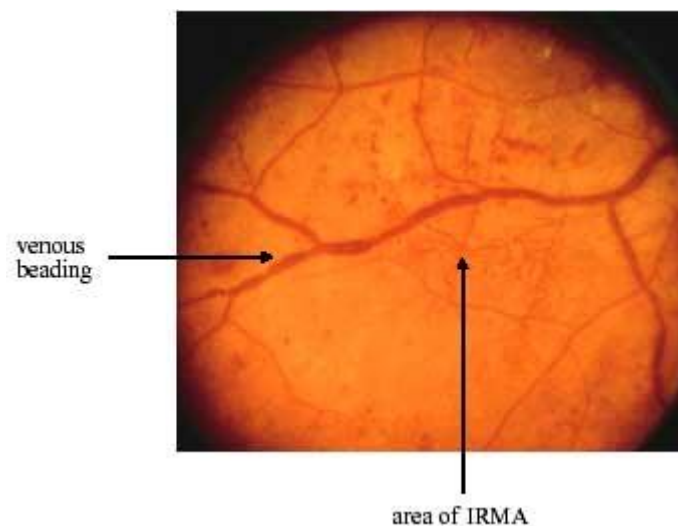
g) Intra-retinal micro-vascular abnormalities

These lesions appear as fine red lines that run from retinal arterioles to venules, thus resembling focal areas of flat retinal vessels. The IRMA's are dilated capillaries that function as

collateral channels often seen closer to areas of capillary closure (Kanski 2003:444). According to Tarr *et al* (2011), IRMA's appear as grey-white patches with fluffy edges representing capillary dilation and new vessels in areas of retinal occlusion and ischemia (See Figure 2.4).

h) Venous and arterial changes

The changes consist of dilatation, looping, beading, and sausage-like segmentation of the veins. Other changes involve narrowing and obliteration of the arteries (Kanski 2003:445). The venous and arterial changes indicate increasing retinal ischemia and predict the progression to proliferative diabetic retinopathy (Tarr *et al* 2011) (See Figure 2.4).



From: <http://www.ndrs.scot.nhs.uk/Train/Handbook/drh-g027.jpg>.

Figure 2.4: Shows venous beading and an area of intra-retinal micro-vascular abnormalities.

i) Dark blot haemorrhages

These represent haemorrhagic retinal infarcts that are located in the middle retinal layers (Kanski 2003:445).

2.3.4.2 Clinical features of proliferative diabetic retinopathy

The hallmark sign of proliferative diabetic retinopathy (PDR) is neovascularisation (Kanski 2003: 447, Paulus and Gariano 2009: 18). The components of PDR include neovascularisation at the disc (NVD) (Figure 2.5), neovascularisation elsewhere in the retina (NVE), and fibrotic proliferation accompanying the neovascularisation, traction retinal detachment, and vitreous haemorrhages (Alexander 1994: 245). It has been estimated that over a quarter of the retina has to be non-perfused before PDR develops (Kanski 2003:447).



From: <http://www.southcoasteye.com/whatsnew.html>.

Figure 2.5: Shows neovascularisation of the optic disc (NVD)

The severity of PDR is determined by the area covered by new vessels in comparison to the area of the disc. If left untreated, the risks are reduced to 4% and 9%, respectively with treatment (Kanski

2003:449). Without treatment, severe NVD with haemorrhage carries a risk of severe visual loss of about 37% within 2 years and risk can be reduced to 20% with treatment. Severe NVE with haemorrhage carries a 30% risk of visual loss, which is reduced to 7% with treatment. Rubeosis iridis have a potential of causing neovascular glaucoma, which may eventually lead to visual impairment, if left untreated (Kanski 2003:454).

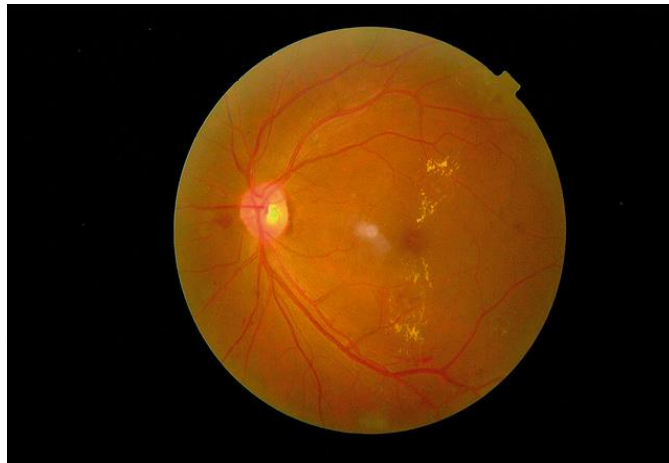
2.3.4.3 Diabetic maculopathy

This is the most common cause of visual impairment, particularly in type 2 diabetic patients. This condition occurs when oedema and hard exudates or ischemia involve the fovea (Kanski 2003: 445).

Clinically significant macular oedema (CSMO) is characterised by the following features:

- i. Retinal oedema within 500µm of the centre of the fovea
- ii. Hard exudates within 500µm of the centre of the fovea, associated with retinal oedema that may be outside 500µm of the central fovea
- iii. Retinal oedema that is one disc diameter (1DD) or larger, any part of which is within 1DD of the centre of the fovea.

The CSMO requires photocoagulation irrespective of visual acuity level. The risk of visual loss may be reduced by approximately 50% by treatment (Kanski 2003:447) (See Figure 2.6).



From:

<http://www.flickr.com/photos/communityeyehealth/5508555009>.

Figure 2.6: Clinically significant macular edema with hard exudates encroaching on the fovea.

2.3.4.4 Classification of diabetic retinopathy

Many authors and organisations have classified diabetic retinopathy in various ways. Originally, diabetic retinopathy was classified into background diabetic retinopathy, pre-proliferative diabetic retinopathy, proliferative diabetic retinopathy and diabetic maculopathy (Table 2.1) (Kanski 2003:447). The Early Treatment Diabetic Retinopathy Study Group (ETDRS)'s classification of diabetic retinopathy includes non-proliferative diabetic retinopathy (NPDR) and proliferative diabetic retinopathy (PDR) with a subcategory of diabetic macula oedema (Table 2.2) (Alexander 1994:241). The severity of NPDR is categorised using the ETDRS acuity scale. In this scale, a numerical value is assigned to reflect the severity as indicated by the presence of the various lesions

associated with NPDR (Table 2.3) (The diabetes control and complications trial research group 1995:38).

Table 2.1: Original classification of diabetic retinopathy

Category	Characteristics
Background diabetic retinopathy	Micro-aneurysms, intra-retinal haemorrhages, hard exudates, retinal oedema
Pre-proliferative diabetic retinopathy	Vascular changes, cotton wool spots, dark blot haemorrhages, intra-retinal micro-vascular abnormalities (IRMA)
Proliferative diabetic retinopathy	Neovascularisation, vitreous detachment, pre-retinal and vitreous haemorrhages
Diabetic maculopathy	Focal maculopathy, diffuse maculopathy, ischaemic maculopathy, mixed maculopathy, clinically significant macula oedema
Clinically significant macula oedema	Retinal oedema within 500µm of the fovea centre, hard exudates within 500µm of the fovea if associated with retinal thickening, retinal oedema that 1500µm or larger, any part of which is within 1DD of the centre of the fovea

Source: Kanski 2003:447

Table 2.2: The Early Treatment Diabetic Retinopathy Study Group classification of diabetic retinopathy

Category	Characteristics
Non-proliferative diabetic retinopathy	Micro-aneurysms, hard exudates, dot-blot and flame-shaped haemorrhages, cotton-wool spots, IRMA, capillary and arteriolar occlusion, venous beading and tortuosity
Proliferative diabetic retinopathy	Neovascularization of the disc (NVD), neovascularisation elsewhere (NVE), fibrotic proliferation, and vitreous haemorrhages
Clinically significant Diabetic macula oedema	Retinal thickening within $\frac{1}{2}$ disc diameter (DD) of centre of the fovea, hard exudates with $\frac{1}{2}$ DD of the fovea, retinal thickening at least 1DD within 1DD of the fovea

Source: Alexander 1994:242

2.3: Abbreviated summary of the final version of the Early Treatment Diabetic Retinopathy study scale of diabetic retinopathy severity for individual eyes

Level	Severity	Definition
10	No DR	DR absent
20	Very mild NPDR	Micro-aneurysms only
35	Mild NPDR	Micro-aneurysms with hard exudates, cotton wool spots, or mild retinal haemorrhages
43	Moderate NPDR	Micro-aneurysms with IRMA or moderate retinal haemorrhages
47	Moderate NPDR	More extensive IRMA, severe retinal haemorrhages or venous beading in one quadrant
53	Severe NPDR	Severe retinal haemorrhages in 4 quadrants or venous beading in at least 2 quadrants or moderately severe IRMA in at least 1 quadrant
61	Mild PDR	NVE < 0.5 DD in one or more quadrants
65	Moderate PDR	NVE ≥ 0.5 DD in one or more quadrants or NVD < 0.25-0.33 DD
71-75	High-risk PDR	NVD $\geq 0.25-0.33$ DD and/or vitreous haemorrhages
81-85	Advanced PDR	Fundus partially obscured

Source: Archives of ophthalmology 1995 113: 36-51

Alexander believes that practitioners should not be concerned about the strict classification of diabetic retinopathy, but should concentrate on what the DR signs indicate and whether they have a potential to cause serious visual loss or not. In addition, practitioners should be concerned about the type of intervention that should be implemented to prevent severe visual loss (Alexander 1994:241). The researcher agrees with Alexander's sentiments and

feels that it should be enough if practitioners could identify DR lesions having the potential of causing visual impairment and introduce appropriate intervention to prevent visual loss and blindness than to know the classification.

2.4 HISTORICAL OVERVIEW OF DIABETIC RETINOPATHY STUDIES

In order for the health authorities to plan for the prevention of visual impairment and blindness due to DM, information on the prevalence and incidence of diabetic retinopathy, as well as the risk factors associated with diabetic retinopathy is necessary. For a long time, there has been very little reliable information on the incidence and prevalence of DR in persons with DM. It was only in the late 1970's that such reliable information became available (Williams, Airey, Baxter, Forrester, Kennedy-Martin & Girach 2004: 967).

The earlier studies that provided reliable data on diabetic retinopathy include the Wisconsin Epidemiological Study of Diabetic Retinopathy (WESDR), The Diabetes Control and Complications Trial (DCCT), The United Kingdom Prospective Diabetes Study (UKPDS). Many regard these studies as the "gold standard" (Williams *et al* 2004: 967). This is probably because they were longitudinal studies conducted using rigid clinical protocols. An overview of the earlier studies is given hereunder.

2.4.1 The Wisconsin Epidemiological Study of Diabetic Retinopathy

The WESDR was conducted in the late 1970's to provide reliable information on the incidence and prevalence of diabetic retinopathy (DR). The study was one of the first studies to document the prevalence and incidence of DR in a large geographically defined population of people with DM (Klein, Klein, Moss, Davis & DeMets 1984: 525). The objectives of the WESDR were as to describe the

prevalence and severity of DR and its component lesions among persons with DM in Southern Wisconsin, to determine the frequency of visual impairment among persons with diabetes in Southern Wisconsin and to determine the relationship between the risk factors, prevalence and severity of DR in persons with diabetes.

A number of follow-up studies were done on the cohort of people with DM in southern Wisconsin to achieve the above objectives. These studies are unique in that a large population of persons with diabetes were examined using standardised protocols and objective recording (Klein *et al* 1984: 525).

The WESDR found that the prevalence of diabetic retinopathy increases with longer duration of DM. Among type 1 DM patients, the prevalence of any DR increased from 2% in those with <2 years duration to 97.5% in those with ≥ 15 years duration of DM. Proliferative diabetic retinopathy (PDR) was not found in type 1 patients with less than 5 years duration of DM. However, the prevalence of PDR was found to increase from 4% in those with 10 years duration to 67% in those with 35 years duration of DM (Klein *et al* 1984:524).

The WESDR also found longer duration of DM and insulin use among type 2 DM patients to be significant risk factors for diabetic retinopathy (DR). The prevalence of any DR among type 2 insulin users was found to be 30% in those with <2 years duration and 84.5% in those with ≥ 15 years duration of DM. For non-insulin users, the prevalence was 23% and 57.5%, respectively, in those with similar duration of DM (Klein *et al* 1984:528). This confirms what is reported above on type 1 patients that the prevalence of DR increases with longer duration of DM. Another notable finding is the fact that the prevalence of DR is higher among insulin users than among non-insulin users. The prevalence of DR was significantly associated with insulin use (Klein *et al* 1984:528). In another study,

however, an insignificant association between the two variables was reported (Klein *et al* 1984:524).

Other variables that were found to be significantly associated with the prevalence of DR are age at diagnosis, age at examination, higher glycosylated haemoglobin, diastolic BP and BMI in people with DM with < 10 years duration of DM. The prevalence of DR was found to be low in children younger than 10 years regardless of duration of DM. Proper control of BP was found to be useful in reducing the development of severe PDR in those with DM for more than 10 years (Klein *et al* 1984: 524).

On the incidence of diabetic retinopathy, the Wisconsin Epidemiologic Study of Diabetic retinopathy (WESDR) found that duration of DM and insulin treatment were significantly associated with the occurrence of diabetic retinopathy. The incidence of DR after 4 years follow-up was approximately 50% in both type 1 and type 2 DM patients, whereas after 10 years follow-up, the incidence was 74% (Klein *et al* 1989: 246a, Klein *et al* 1994:1217). This indicates that the longer duration of DM is associated with higher incidence of DR. The 4-year incidence of any DR among insulin users (47%) was higher than among non-insulin users (34%); similarly, the incidence of PDR was higher among insulin users (7%) than among non-insulin users (2%) (Klein *et al* 1989: 246a).

After 10 years follow-up, the incidence rate increased to 89% for type 1 and 79% for type 2 insulin users; for non-insulin users the incidence rate rose to 67% (Klein *et al* 1994:1217). The risk of developing any DR during the first decade among type 1 patients was found to be low. The incidence of PDR in type 1 patients with <15 years duration was found to be higher in those with longer duration than those with shorter duration of DM. However, in those with ≥15 year duration, the incidence of PDR in those with longer duration was lower when compared to those with shorter duration (Klein *et al* 1989:240b).

The WESDR reported that 8% of type 1 DM patients had visual impairment (VA of worse than 6/12 with correction) at baseline. As with diabetic retinopathy, the prevalence of visual impairment was found to increase with increasing age. No cases of legal blindness among patients who were below the age of 25 years were reported (Klein & Klein 1995:296).

Among type 2 patients, the rate of blindness also increased with increasing age. The rate of blindness was higher among non-insulin users (2.2%) than among insulin users (1.6%). The prevalence of legal blindness was associated with longer duration of DM. Among type 1 patients, the prevalence of blindness increased from 3% in those with 15-19 years duration to 12 % in persons with diabetes for ≥ 30 years. Among type 2 patients, the prevalence of legal blindness was relatively lower, and reached only 7% in patients having DM for 20-24 years. The major cause of blindness among type 1 patients was diabetic retinopathy. However, among type 2, DR was not the major cause of blindness, instead cataracts and macular degeneration were the major causes (Klein & Klein 1995:296).

2.4.2 The Diabetes Control and Complications Trial

The Diabetes Control and Complications Trial (DCCT) was a clinical study conducted from 1983 to 1993 by the National Institute of Diabetes and Digestive and Kidney diseases. The study was done on type 1 DM patients from 29 medical centres in Canada and the United States of America. The study was designed to assess whether proper control of blood glucose level as close to the non-diabetic range as possible may reduce the incidence and progression of the retinal vascular abnormalities, including diabetic retinopathy. The DCCT conclusively demonstrated that intensive control of blood glucose levels and blood pressure substantially reduces the risk of onset and progression of diabetic retinopathy, and the need for laser surgery (Fong, Aiello, Gardner, King,

Blankenship, Cavallerano, Ferris & Klein 2003: s99). This is in agreement with the findings in the WESDR studies discussed above (Klein *et al* 1984: 524).

Retinal photographs of 1613 type 1 DM patients of <5 years duration were used as part of the screening for admission to the study. Of the 1613 subjects with <5 years duration of DM, 54.1% had diabetic retinopathy (DR) at baseline. The prevalence of DR in those with 1-year duration was 19.4%, and in those with 4-5 year duration, the prevalence increased to 48.4% (Malone, Morrison, Pavan & Cuthbertson 2001:523). The increase in the prevalence of DR with longer duration of DM is in agreement with reports from WESDR studies. However, the prevalence (54.1%) of DR in those with < 5 years duration is much higher than the 21% reported in the WESDR study (Klein, Klein & Davis 1983:233). Additionally, the 19.4% prevalence of DR observed in those with 1 year duration is much higher than the 2% reported by Klein *et al* (1984:524) in those with <2 years duration. The 19.4% prevalence of DR in those with 1 year duration suggests that dilated fundus examinations should be performed a year after diagnosis of type 1 DM.

2.4.3 The United Kingdom Prospective Diabetes Study

The United Kingdom Prospective Diabetes Study (UKPDS) was a 20-year study involving 23 centres in the UK with more than 5000 patients with newly diagnosed type 2 DM. The study was conducted to determine whether intensive use of pharmacological therapy to control DM reduces cardiovascular and micro-vascular complications or not, and whether the use of various sulfonylurea drugs, metformin or insulin has specific advantages or disadvantages. In those with hypertension, the study was to determine whether there were any benefits in lowering BP and whether the use of ACE inhibitor (captopril) or β -blocker (atenolol) offered particular advantages or disadvantages (American Diabetic Association 1999).

The UKPDS revealed that better blood glucose control reduces the incidence and progression of retinopathy by 25% and of nephropathy by 33%. The overall micro-vascular complication was reduced by 25%. These findings support the increased evidence that hyperglycaemia causes, or is a major contributor to these micro-vascular complications. The UKPDS data showed that for every percentage point decrease in HbA1c (e.g. from 9 to 8%), there was a 35% reduction in the risk of the complications. Lowering blood pressure to a mean of 144/82 mmHg significantly was found to reduce strokes, diabetic-related deaths, heart failure, micro-vascular complications, and visual loss (American Diabetic Association 1999)

A study conducted on 1148 type 2 DM patients with hypertension by the UKPDS Group in England, Scotland and Northern Ireland, revealed that tight BP control achieved a clinically important reduction in the risk of diabetes-related deaths, diabetes-related complications, progression of DR and visual loss. The reduction in the risk of any diabetes-related end-point was 24%. For diabetes-related deaths, stroke, and for micro-vascular diseases, the risk reduction was 32%, 44%, and 37%, respectively. The mean BP on patients on tight BP control was 144/82mmHg over 9 years when compared with 154/87mmHg for those on less tight BP control (UKPDS Group 1998:707). The finding that BP control reduces the progression of DR concurs with reports from the WESDR and DCCT studies (Fong *et al* 2003:s99, Klein *et al* 1984:524).

The fact that good blood glucose and BP control minimises the development of DR was re-affirmed in another UKPDS study. The study was done to determine the risk factors related to the incidence and progression of diabetic retinopathy (DR) over 6 years from diagnosis of type 2 DM. Retinal photographs were taken on 1919 patients with newly diagnosed type 2 DM. Of the 1919 patients, 703 (37%) had retinopathy and 1216 (63%) had no retinopathy at diagnosis (Stratton, Kohner, Aldington, Turner, Holman, Manley & Matthews 2001: 158). The incidence of DR (micro-aneurysms in both

eyes and worse) over 6 years was 22%. In those with DR at diagnosis, 29% progressed by two steps or more (from very mild non-proliferative diabetic retinopathy (NPDR) to moderate NPDR or worse). The incidence of DR was strongly associated with baseline hyperglycaemia, hyperglycaemic exposure over 6 years, high blood pressure and not smoking. On the other hand, DR progression was associated with older age, male sex and higher HbA1c (Stratton *et al* 2001: 158).

2.4.4 The Early Treatment of Diabetic Retinopathy Study

The ETDRS was a multi-centre, randomised clinical trial to evaluate the effectiveness of argon laser photocoagulation and aspirin therapy in delaying or preventing progression of early DR to more severe stages of visual loss and blindness. Three thousand seven hundred and eleven (3711) patients were recruited for the study and were followed for a minimum of 4 years (Davis, Fisher, Gangnon, Barton, Aiello, Chew, Ferris III & Knatterud 1998:244).

The main results for the ETDRS can be summarised as follows:

- i. Aspirin has no clinically important beneficial or harmful effect on the progression of retinopathy, and therefore there is no ocular contraindication to its use when required to treat other diseases.
- ii. Focal treatment of macula oedema with photocoagulation reduced the risk of moderate visual loss in patients with oedema that threatened the centre of the macula. Retinal oedema decreased in eyes that received focal treatment. All eyes with CSMO should be treated with focal photocoagulation.
- iii. A statistically significant reduction in severe visual loss was reported for those eyes with early scatter treatment. However, it was recommended that scatter treatment should be deferred in those eyes with mild to moderate NPDR, and that it should be considered once retinopathy progresses to severe NPDR or

early PDR. All eyes with high-risk PDR should be considered for scatter photocoagulation.

- iv. Early vitrectomy should be considered for advanced active PDR.
- v. Duration of DM and severity of hyperglycaemia are important risk factors for the development of DR. If DR is present duration appears to be of little significance, but the degree of hyperglycaemia remains an important risk factor

The rate of blindness in the ETDRS following the onset of PDR was remarkably low. Legal blindness for patients with PDR for 5 years was reduced to <5%, whilst severe visual loss was reduced to 1%. Before the current treatments, the prognosis for patients with PDR was blindness within 5 years for more than 50% of the patients (Prevent Blindness America 2005) Unfortunately, this situation is likely to continue in most parts of the world, especially in developing countries where resources to deal with DR are scarce. Countries that do not have enough ophthalmologists and health facilities to implement these current treatments should come up with other means to prevent or delay the incidence and progression of diabetic retinopathy to severe stages of DR.

Subsequent to the “gold standard” studies, a number of other studies have been conducted in many parts of the world. A few of the studies recruited large numbers of patients, whilst the majority of the studies recruited smaller numbers of patients. Most studies that the researcher found in literature focussed on different aspects of diabetic retinopathy, such as the prevalence, incidence, progression, risk factors etc. The researcher feels that these studies are relevant to the present study, because diabetic retinopathy is the number one cause of visual and blindness in persons with DM. The researcher reviewed the studies that were found in literature and where possible, findings from the various studies were compared with findings from the “gold standard” studies. The studies were discussed under the following headings: prevalence of DR, incidence

and progression of DR, prevalence and incidence of visual impairment, screening and management of DR.

2.5 A REVIEW DIABETIC RETINOPATHY STUDIES

The prevalence of diabetic retinopathy (DR) in the general population is dependent on the prevalence of DM itself, because only persons with DM can have diabetic retinopathy.

Prevalent cases are the number of people who have a particular disease at a specific time;

$$\text{Prevalence} = \frac{\text{all cases}}{\text{Total population at risk of the disease}}$$

(Katzenellenbogen, Joubert, Abdool 1997:17)

There are more reports on the prevalence and incidence of diabetic retinopathy in literature than there are on the prevalence and causes of visual impairment and blindness among people with diabetes. Consequently, most of the studies reviewed in the present study are on diabetic retinopathy. The prevalence of retinopathy has been observed to vary in the different studies that the researcher has reviewed. In some instances, the prevalence varied because of differences in for instance, the definitions, methodologies, demographic characteristics of the study populations and so on.

2.5.1 The prevalence of diabetic retinopathy in the developed countries

The Eye Diseases Prevalence Research Group (EDPRG) used the data from the National Health Interview Survey (NHIS) to determine the prevalence of diabetic retinopathy among adults 40 years and older in the United States. The estimated US general population DR prevalence rates (level 14 or higher in the ETDRS scale) among persons known to have DM was 3.4% (4.1million persons), and the prevalence of those with Vision Threatening Diabetic Retinopathy

(VTDR) (level 50 or higher in the ETDRS scale) was 0.75% (899,000 persons). These figures would decrease to 2.81 % (3.4 million) and 0.57% (680,000), if the WESDR data were excluded. Among the estimated 10.2 million US adults 40 years and older, the estimated crude prevalence rates for retinopathy and vision threatening retinopathy were 40.3% and 8.2%, respectively (The Eye Diseases Prevalence Research Group 2004:556)

There was very little difference between the prevalence of diabetic retinopathy and age. As with age, no consistent association existed between sex and the prevalence of diabetic retinopathy. In contrast, there was an association between race and the prevalence of diabetic retinopathy, with the Hispanic participants having a higher prevalence of diabetic retinopathy than the black participants do (The Eye Diseases Prevalence Research Group 2004:556). The prevalence of DR in this study is much lower than the 54.1% reported in the Diabetes Control and Complications Trial study among type 1 DM patients with <5 years duration (Fong *et al*, 2003:s99).

A study to determine the prevalence and risk factors of diabetic retinopathy (DR) among adults aged 40 years and older in the United States, found the prevalence of DR and vision threatening diabetic retinopathy (VTDR) to be 28.5% and 4.4%, respectively. Approximately 1.5% of the diabetic adults had PDR and 2.7% had CSMO. No significant difference was noted in the prevalence of DR and VTDR between those aged 40-64 years and those aged 65 years and older. The risk factors for prevalence DR in the study were longer duration of DM, higher HbA1c, higher systolic BP, male sex, and insulin use (American Medical Association 2010).

In a population-based study to investigate the prevalence and risk factors of diabetic retinopathy (DR) in 1588 subjects aged 40 years and older in Casteldaccia, the prevalence of DR was found to be 4.4% among all the subjects and 34.1% among the people with DM.

Of this 34.1%, 29.5% had NPDR and 4.5% had PDR. The prevalence of DR was observed to increase with increasing age. Long lasting treatment with oral hypoglycaemic agents and insulin treatment even for a short period was significantly associated with the presence of DR (Giuffrè, Lodato & Dardanoni 2004:537).

In a study to determine the prevalence of diabetic retinopathy (DR) and causes of visual impairment among 378 type 2 DM patients in Århus county, Denmark, the prevalence of DR was 31.2%. Proliferative diabetic retinopathy was detected in 2.9% of the patients, all of whom had been treated with pan-retinal photocoagulation, and 5.3% had CSMO, of whom 40% had been treated with laser photocoagulation. Long duration of DM, high HbA1c level, high systolic blood pressure, and the use of insulin were significantly associated with severity of DR, whilst age, sex, diastolic blood pressure, oral diabetic medication, antihypertensive medication were not significantly associated with severity of DR (Hove, Kristensen, Lauritzen & Bek 2004:446).

In another study in Fyn County, Denmark, the prevalence of DR among 201 type 1 DM patients was 97%. Of this percentage, 45.8% had non-proliferative diabetic retinopathy (NPDR) whilst 52.9% had proliferative diabetic retinopathy (PDR). No differences in prevalence between males and females were noted (Grauslund, Green & Sjølie 2009:1831).

In a study to describe the proportion and characteristics of DR in France, Spain, Italy and the UK, the prevalence of DR among 752 patients was 11.4%, 10.3%, 19.7%, and 19.6%, respectively. The majority of the patients with DR had mild NPDR. Approximately 73% of the patients recruited had hypertension and 50% of those with DR had other micro-vascular complications, such as nephropathy (49.4%) and peripheral neuropathy (52.1%). The severity of DR was related to longer duration of DM and frequency of all co-morbidities studied, particularly nephropathy and coronary heart disease. Among

the 752 patients with DR, 8.8% had diabetic macula oedema (DMO) in one eye only and 6.5% had DMO in both eyes. Type 1 patients were more likely to have PDR compared with type 2 patients (Rubino, Rousculp, Davis, Wang & Girach 2007).

In a population-based study to estimate the prevalence and healthcare costs of diabetic retinopathy in Sweden, the prevalence of diabetic retinopathy (DR) among the 12,206 diabetes patients was 29.2%. The prevalence of DR was higher among type 1 patients (41.8%) than among type 2 patients (27.9%). The prevalence of DR was significantly higher for men (30.9%) than for women (27.4%). Sight –threatening retinopathy such as proliferative diabetic retinopathy and maculopathy was present in 5.7% of the patients (Heintz, Wiréhn, Peebo, Rosenqvist & Levin 2010:2151).

2.5.2 The prevalence of diabetic retinopathy in the developing countries

The prevalence of DR in a cross-sectional study conducted among 152 patients with newly diagnosed type 2 DM in Tehran was 13.8%. Among the patients with DR, 14.3%, 47.6%, 23% and 4.8% had micro-aneurysms only, mild NPDR, moderate PDR, and high-risk PDR, respectively. Diabetic retinopathy was significantly associated with age ($p=0.03$), duration of DM ($p=0.001$), fasting plasma glucose ($p=0.003$), HbA1c ($p=0.000$), and systolic blood pressure (0.005) (Abdollahi, Malekmadani, Mansoori, Bostak, Abbaszadeh & Mirshahi 2006: 416).

In a population-based study in Tehran Province among 634 patients with DM, the prevalence of any DR in 2007 was 37%. The prevalence of DR increased from 22.3% in those with <5 years duration of DM to 74.5% in those with ≥ 15 years duration. The prevalence of PDR, Vision Threatening Diabetic Retinopathy (VTDR), Clinical Significant Macula Oedema (CSMO), was 9.6%, 14%, and 5.8%, respectively. The prevalence of DR was significantly associated with longer

duration of DM, male sex, oral medication or insulin treatment, presence of hypertension and nephropathy (Javadi, Katibeh, Rafati, Dehghan, Zayeri, Yaseri, Sehat & Ahmadi 2009). The prevalence of DR (37%) in this study is higher than the 13.8% reported in another Tehran study by Abdollahi *et al* (2006:416). The reason for the difference may be that this study was a population-based study and the one by Abdollahi *et al* (2006) was a clinic-based study. The 37% prevalence of DR reported in this study is similar to what was reported in the United Kingdom Prospective Diabetes Study by Stratton *et al* (2001:158), but is lower than the 54.1% reported in the Diabetes Control and Complications Trial study by Malone *et al* (2001:523).

The prevalence of diabetic retinopathy in the study done on 513 diabetic patients in Al-Ain city, United Arab Emirates was 19%. Of this percentage, background diabetic retinopathy was seen in 13.8%, PDR in 3.8% and advanced eye diseases in 1.7% of the patients. Diabetic retinopathy increased from 6.7% in those with <5 years duration to 52.2% in those between 11-20 years. Diabetic retinopathy was significantly higher in type 1 DM (38.3%) when compared with type 2 DM (16.4%) ($p < 0.0001$). Diabetic retinopathy was significantly associated with male sex

(24.2% versus 13.9%, $p = 0.016$), age ($p = 0.004$) and duration of DM ($p = 0.0001$) (Al-Maskari & El-Sadig, 2007). The prevalence of DR was higher than the one reported by Abdollahi *et al* (2006:416) in the above study. The prevalence of DR in this study is, however, similar to that reported in Italy (19.7%) and the UK (19.6%) by Rubino *et al* (2007). The prevalence of DR in persons with a duration of <5 years and those with duration of ≥ 15 years in this study is less than those reported in the WESDR studies (Klein *et al* 1983:233, Klein *et al* 1984:524) for similar duration.

In a study to estimate the magnitude and risk factors of DR among 350 patients in Yemen, the prevalence of DR was 55%. The prevalence ranged from 18.6% in those with <5 years to 87% in

those with ≥ 15 years duration of DM. The prevalence of pre-proliferative diabetic retinopathy, PDR, macula oedema, and rubeosis iridis was 13%, 17%, 22%, and 4.6%, respectively. The prevalence of DR was higher among insulin users (74%) than non-users (44%). The prevalence of DR significantly increased with longer duration of DM (chi-square=33.9, degree of freedom=3, $p < 0.001$) (Bamashmus, Gunaid & Khandekar 2009:294). The prevalence of DR (55%) in this study was higher than the 13.8%, 19% and 37% reported by Abdollahi *et al* (2006), Al-Maskari *et al* (2007) and Javadi *et al* (2009), respectively. In persons with DM of ≥ 15 years duration, the prevalence of DR in this study was higher than that reported by Al-Maskari & El-Sadig (2007) and Javadi *et al* (2009). However, the prevalence in this study was lower than the 97% reported by Klein *et al* (1983:233) and Klein *et al* (1984:524).

In a population in southern India, the prevalence of DR in 260 people who reported that they had DM was 26.8%. Approximately 94% of those with DR had NPDR and 29% had CSMO. Two eyes were blind (VA $< 6/60$) due to diabetic retinopathy. Diabetic retinopathy was significantly associated with duration of DM of > 10 years and current use of insulin (Narendran, John, Raghuram, Ravindran, Nirmalan & Thulasiraj 2002: 1016).

In a study to assess the prevalence, potential risk factors for diabetic retinopathy in the Indian state of Andhra Pradesh, the prevalence of DR among 201 people with DM was 19.4%. Of this percentage, 51.3% had mild NPDR, 35.9% moderate NPDR, 7.7% severe NPDR, and 2.6% PDR. Increasing age, socioeconomic status, and duration of DM were significantly associated with increasing risk of DR. The odds of DR prevalence were significantly higher in the urban residents (Odds ratio (OR)= 6.17 95% confidence interval (CI) = 2.84-12.98) middle and upper socioeconomic group (OR=2.34, 95%CI=1.16-4.73) and in persons with hypertension. Duration of DM ≥ 15 years was also significantly associated with the risk of DR (OR=8.62, 95%CI=2.63-28.29) (Krishnaiah, Das, Nirmalan,

Shamanna, Nutheti, Rao & Thomas 2007:478). The prevalence of DR in this study is lower than the one reported by Narendran (2002:1016) in the above study.

In another study conducted in 3 southern districts of India involving 26529 participants, the prevalence of DR was 17.6% and the prevalence of sight-threatening DR (severe NPDR, PDR and CSMO) was 5.3%. Males were found to be at higher risk of developing DR than females. Longer duration of DM, lean BMI, higher systolic blood pressure and insulin use were significant risk factors for DR (Rani, Raman, Chandrakantan, Pal, Perumal & Sharma 2009). Duration of DM and insulin use was found to be significant risk factors in both of the studies in southern India. However, the prevalence of DR was higher (26.8%) in the study by Narendran *et al* (2002) than the prevalence (17.6%) reported by Rani *et al* (2009). The difference could be due to differences in the age range of the participants recruited in the two studies.

In a study to evaluate the magnitude of DR and other co-morbidities among diabetic patients in Sumail Hospital of Oman, the prevalence of DR among those who visited the Hospital in 2006 was 7.89%. No DR was present among patients who were 40 years or younger. The prevalence of NPDR was 11.2% and PDR was present in only one eye. There was no difference in the risk of DR between male and female. Other co-morbidities included trachomatous opacities and cataracts (Khandekar, Tirumurthy, AL-Harby, Moorthy & Amir 2009:676).

In a project in Ahmedabad, India, to evaluate the magnitude and determinants of DR and other ocular complications among people with DM, the prevalence of DR was 9.74%. The number of persons with DM was 13887. Of this number, 66.6% knew that they had DM and 33.3% did not know that they had DM. Male sex (Odds ratio (OR)=1.31), family history of DM (OR=1.32), duration of DM (Chi-square= 1.808), hypertension (OR=0.72), poor glucose control

(OR=0.09), and nephropathy (OR=2.16) were associated with the presence of DR. There was an increased risk of visual impairment and blindness in persons with DR (16%) compared to those without DR (4.7%). Glaucoma was present in 5.2% of the persons with DM (Vyas, Khandekar, Trivedi, Desai & Danayak 2009:603).

In a study to estimate the prevalence of diabetic retinopathy (DR) among 660 newly diagnosed adults with DM in Pakistan, the prevalence of DR was 15.3% (101/660). Of these, fifty-six (55.4%) were female and forty-five (44.5%) were male. The overall prevalence of diabetic retinopathy among all the participants (16507) 30 years and above was 0.6%. The prevalence of DR was found to be higher in females (0.64%) than in males (0.58%) and lower in rural (0.38%) than urban areas (1.08%). The prevalence of DR increased with increasing age, from 0.08% at the age group of 30-39 years to 1% at the age group of 70years and above. The prevalence was higher in those with hypertension (0.95%) than in those without (0.5%) and in obese participants (1.09%) compared to lean participants (0.51%) (Shaikh, Shaikh, Shaikh & Ahmed 2008:777).

In a study to determine the frequency of type 2 DM and to evaluate the status of diabetic retinopathy in Pakistan, the prevalence of DR among 1677 patients was 27.33%. Most of patients 334/460 (72.61%) had non-proliferative diabetic retinopathy (NPDR) without clinical significant macula oedema (CSMO), while a few 126/460 (27.36%) had advanced retinopathy with threatening CSMO requiring immediate attention. Of the 126 patients, 96 (20.87%) had proliferative diabetic retinopathy (PDR), 10 (2.17%) had NPDR+CSMO, and 12 (2.61%) had PDR+CSMO, all requiring laser treatment to stabilise their vision from further deterioration (Mahar, Awan, Manzar & Memon 2010:529).

In a population-based study to determine the prevalence and characteristics of diabetic retinopathy in Faisalabad, Pakistan among 1524 patients, the prevalence of diabetic retinopathy was

found to be 183(12%). Of these, 106(7%) had NPDR and 77 (5%) had PDR. Clinically significant macula oedema was found in 1.2% of the patients. The number of people with DR was higher in type 1 patients when compared with type 2 patients (Hussain, Arif & Ahmad 2011:737).

A population-based study to describe the risk factors associated with diabetic retinopathy among 387 rural Chinese type 2 patients found the prevalence of diabetic retinopathy (DR) to be 43.1% (95% confidence interval (CI) 38.1-48.4%, after age-standardised to the Chinese population in the year 2000 China population census). After adjusting for age and gender, factors that were significantly associated with the presence of DR were longer duration ($p<0.001$), oral hypoglycaemic agents or insulin ($p<0.001$), higher fasting plasma glucose level ($p<0.001$) and higher systolic blood pressure ($p=0.03$). Factors that were not significantly associated with DR include marital status, education, cigarette smoking, alcohol consumption, history of stroke, coronary heart disease, aspirin use, and use of contraceptive (Wang, Liang, Peng, Wang, Zhang, Wei, Sun, Friedman, Wang, Wong & the Handan Eye Study Group 2011:e339).

In a population-based study to investigate the prevalence of diabetic retinopathy (DR) and its associated factors among 1298 rural Korean type 2 DM patients, the overall prevalence of DR was 18%. Of this percentage, 16.7% had non-proliferative diabetic retinopathy (NPDR) and 1.3% had proliferative diabetic retinopathy (PDR). The prevalence of mild, moderate, and severe NPDR was 9.7%, 3.2%, and 3.7%, respectively (Kim, Kwon, Park, Lee, Kim, Yoon, Lee, Cha & Son 2011:1070).

In univariate analysis, the incidence of DR was associated with duration of DM, postprandial blood glucose levels, and diabetic foot. In logistic regression model, DR was significantly associated with duration of DM, postprandial blood glucose levels and glycosylated

haemoglobin (HbA1c). The risk of DR increased with longer duration (5-10 years: OR=5.19; >10 years=10.03, <1 year as a reference), and was 2.5 fold greater in patients with postprandial glucose levels >180md/dl compared to patients with postprandial glucose levels of <180md/dl. For every 1% increase in HbA1c, the risk of DR increased by a factor of 1.34 (95%CI: 1.545-1.980) (Kim *et al* 2011:1070)

In a study in 5 centres in Ghana and Nigeria aimed at quantifying the prevalence of, risk factors for, DR and cataracts among 840 type 2 patients, and their 191 control spouses. The prevalence of DR was 17.9% across the 5 centres. There was an association between the prevalence of DR and duration of DM. The occurrence of DR was higher in men than in females. The prevalence of cataract was higher among people with DM (44.9%) than among the controls (18.3%) (Rotimi, Zhou, Obisesan, Chen, Chen, Amoah, Opoku, Acheampong, Agyenim-Boateng, Eghan, Oli, Okafor, Ofoegbu, Osotimehin, Abbiyesuku, Johnson, Fasanmade, Doumatey, Aje, Collins & Dunston 2003:S2-112). This confirms the fact that people with DM have an increased risk of cataract compared to the general population. More than 50% of persons with DM for >20years had DR, and nearly 70% had cataracts. There was a significant association between glucose levels and both DR and cataracts. Duration of DM and the level fasting plasma glucose were the two most important risk factors for DR. Hypertension (53%) was higher among the type 2 patients than among the controls (37%). The BMI was $25 \pm 4.3 \text{ kg/m}^2$ for men and $27.5 \pm 5.8 \text{ kg/m}^2$ for females (Rotimi *et al* 2003:S2-112).

A cross-sectional study to investigate and correlate between the contributing role of obesity as detected by BMI, lipids, lipid intake, and protein intake to retinopathy severity was conducted among 149 type 2 DM patients. Approximately 69% of the patients had DR of varying degrees. Of these patients, 48.3% had mild NPDR, 5.4% had moderate NPDR, 4% had severe NPDR and 9.4% had PDR. Higher BMI was significantly associated with reduced visual acuity and

increased severity of DR. There was a significant positive correlation between DR and BMI, duration, high-energy diet, increased carbohydrate intake, total proteins and unsaturated fats (Elshazly, Samy & Sebaay 2010:6235).

The researcher found very few studies in literature on the prevalence of diabetic retinopathy in South Africa. A study was conducted in Hlabisa District in the Kwazulu-Natal Province to describe the diabetic population serviced by the Public Health Sector, and to assess the level of DM control as well as the extent of DM complications (Rotchford & Rotchford 2002:538). Of the 253 people with DM who were examined and interviewed in that study, the prevalence of any DR, PDR, macula oedema and severe visual loss or blindness in at least one eye was 40.3%, 5.6%, 16.2% and 42.8%, respectively. Diabetic retinopathy was positively associated with duration of DM, age, HbA1c, and negatively with BMI. Females were 3 times at risk for DR than males. Approximately 94% of the subjects reported that they take their medications as prescribed. The mean BMI among the subjects was $31.2 \pm 6.9 \text{ kg/m}^2$; obesity ($\text{BMI} > 27$) was present in 63% of the subjects and 36.5% were severely obese ($\text{BMI} > 33$) (Rotchford & Rotchford 2002:538).

In a study to establish whether an experienced endocrinologist could screen accurately for diabetic retinopathy (DR) using mydriatic fundus camera compared with a reference standard in South Africa, the prevalence of any DR among 1517 DM patients was approximately 30%, and 12% of the eyes had severe DR that warranted referral. Severe DR was more common in blacks (58.6%) when compared with Indians (54.4%) and whites (42.3%). The severity of DR was significantly associated with longer duration of DM (Carmichael, Carp, Welsh & Kalk 2005:57).

In another study that was aimed at the implementation and evaluation of a new service for retinal screening that uses non-mydriatic fundus camera in South Africa, the prevalence of DR

among 400 DM patients was 63%. Of this percentage, 22% had severe NPDR, 6% had PDR and 15% had maculopathy (Mash, Powell, du Plessis, van Vureen, Michalowska & Levitt 2007:1286).

In a study conducted at a primary clinic in Cape Town to evaluate the DR status of patients and to assess the adequacy of the current screening programmes. The prevalence of any DR in 248 patients seen at the clinic was 32.3% and that of Sight Threatening Diabetic Retinopathy (STDR) was 8.9% (Read & Cook 2007:61).

2.5.3 The Incidence and progression of diabetic retinopathy

Incident cases refer to the number of new cases reported during a specified period in a defined population.

$$\text{Incidence} = \frac{\text{New cases}}{\text{Healthy population at risk of a disease at the start of a period}}$$

(Katzenellenbogen *et al* 1997).

Progression of a disease refers to the change in the disease state from mild to moderate or moderate to severe state. For instance, diabetic retinopathy may progress from background diabetic retinopathy (BDR) to pre-proliferative diabetic retinopathy (PPDR). The natural history of diabetic retinopathy from no diabetic retinopathy (NDR), BDR, PPDR, PDR, and finally blindness were quantified in a study done on 795 patients in Taiwan between 01 January 1990 and 31 December 1992 (Liu, Lee, Yent, Tung, Williams, Duffy & Chen 2003:729). The study revealed that the average times spent in states of NDR, BDR, PPDR, PDR, were 10.86 years, 8.33 years, 1.67 years, and 2.17 years, respectively. This suggests that the natural history of DR from NDR to blindness is a long process, which would afford enough opportunity for the prevention of diabetic blindness.

It is estimated that early detection and treatment may lead to 60% reduction in progression of DR from PPDR to PDR, and 57%

reduction in the progression from PDR to blindness. The annual incidence rate of DR was 11%. The annual regression rate from BDR to NDR following early detection and treatment was 3%, whereas the annual progression rate to PDR was 5%. The study found that annual screening of those with NDR was unlikely to be considerably more effective than a 4-year screening interval. Consequently, a 4-year screening interval was recommended for those with NDR (Liu *et al* 2003:729).

In Australia, a study to document the five-year incidence and progression of diabetic retinopathy (DR) in the Melbourne Visual Impairment Project cohort found the incidence of DR to be 11 % among 121 patients without any signs of DR at baseline. The progression of DR in those who had DR at baseline was 29%, and the progression to PDR was 2.9%. The 5-year incidence of macula oedema was 8%. The following factors were not found to be associated with incidence and progression of diabetic retinopathy: age, sex, self-reported hypertension, use of antihypertensive medication, and use of insulin, duration of DM and body mass index. Only glycosylated haemoglobin was found to be significantly associated with incidence and progression of DR (McCarty, Fu, Harper, Taylor & McCarty 2003:399).

The incidence and progression rates of DR in this study were lower when compared to those reported by Klein *et al* (1984:524) and Klein *et al* (1989:246) in the Wisconsin Epidemiological Study of Diabetic Retinopathy studies. In this study, the incidence and progression of DR were significantly associated with only glycosylated haemoglobin. However, Klein *et al* (1989:246) reported duration of DM as the only significant factor for the incidence and progression of DR.

Another study in Australia reported a 5-year cumulative incidence of DR of 22.2%. The progression of DR after 5-year follow-up was 25.9%, and regression of DR during the same period was 11.5%.

After five years, the progression to PDR in those with DR at baseline was 4.2%. Fasting blood glucose level and duration of DM were the only statistically significant risk factors for progression of DR. The risk of progression was found to be 2.8 times higher (after 5 years follow-up) when both the fasting blood glucose of ≥ 10 mmol/l and duration of DM of ≥ 10 years were present at baseline examination (Cikamatana, Mitchell, Rochtchina, Foran & Wang 2007:468). The 22% incidence of DR is similar to the one reported in the UKPDS study by (Stratton *et al* (2001:158). The incidence of DR and progression to PDR were higher when compared with those reported by McCarty *et al* (2003:399) in the above study. The progression of DR was, however, slightly lower than what McCarty *et al* (2003:399) reported. When compared with the WESDR findings by Klein *et al* (1989:246), the incidence and progression of DR in this study were low.

The overall 4-year incidence of DR in Los Angeles was 34%. The incidence decreased significantly with age; the incidence ranged from 45.5% in those who were 40-49 years old to 24.3% in those who were ≥ 70 years old. Duration-specific incidence ranged from 20.4% to 55.1% (10-14 years), then dropped to 39.5% in those who had had DM for ≥ 15 years. Of people with DM with DR at baseline, the progression of DR was noted in 38.9%. Progression of DR decreased significantly with age. Progression ranged from 58.2% for those who were 40-49 years old to 25% in those who were ≥ 70 years old. Duration of DM was not significantly associated with progression of DR (Varma, Choudhury, Klein, Chung, Torres, Azen & the Los Angeles Latino Eye Study group 2010).

In a study in Fyn County, Denmark, the 25-year incidence of PDR was 42.9% for all patients at risk. The presence of NPDR and high HbA1c at baseline were the only risk factors for the incidence of PDR. Duration of DM, proteinuria, smoking, BMI, maculopathy and diastolic blood pressure were not associated with the incidence of PDR (Grauslund *et al* 2009:1831).

2.6 THE PREVALENCE AND INCIDENCE OF VISUAL IMPAIRMENT AND BLINDNESS AMONG DIABETES PATIENTS

As indicated earlier, reports on the prevalence and incidence of visual impairment and blindness among people with diabetes are limited. Some of the studies that were found in literature are discussed hereunder.

In the Behavioural Risk Factor Surveillance System (BRFSS) survey conducted in 1995 among 85,447 participants to investigate the prevalence of visual impairment among adults with DM in the United States; the overall prevalence of visual impairment was 24.8%, and it increased significantly with age and was significantly higher in females than males. After adjustment for age, the odds of having impaired vision were reported to be 70% higher for persons with type 1 DM (Odds ratio (OR) =1.7; 95% confidence interval (CI) =1.0-2.9; $p=0.02$) and 40% higher for those with type 2 DM (OR=1.4, 95%CI=1.03-1.9; $p=0.02$) who used insulin compared with nonusers. Among insulin users, visual impairment decreased significantly with increasing level of education ($p<0.01$). The unemployed and retired individuals were more likely to have visual impairment, when compared to those who were employed ($p<0.01$) (Saaddine, Narayan, Engelgau, Aubert, Klein & Beckles 1999:1201).

Roy (2000:102) conducted a study in New Jersey to determine the frequency and severity of diabetic retinopathy, as well as associated visual impairment, among 725 African Americans with type 1 DM. Visual impairment ($VA \leq 6/12$ in the better eye) was found in 11% and legal blindness ($VA \leq 6/60$ in the better eye) in 3.1% of the participants. The frequency of visual impairment was significantly associated with older age and female sex and only weakly with lower education.

Roy & Skurnick (2007) conducted a follow-up study in the New Jersey 725 to determine a 6-year incidence of visual loss and

associated risk factors in African Americans with type 1 DM mellitus. It was found that 4.3% of the patients developed visual loss ($VA \leq 6/12$) in the better eye, 0.6% became blind ($VA \leq 6/60$), 9.8% developed doubling of the visual angle (DVA) in the better eye, and 13.5% developed DVA in either eye. The incidence of visual loss in the better eye and DVA in the better eye or either eye increased significantly with increasing age and duration of DM at baseline ($p < 0.001$). There were no significant associations between DVA in either eye and level of education ($p = 0.3$), socioeconomic status ($p = 0.91$), marital status ($p > 0.99$), personal income ($p = 0.52$), BMI ($p = 0.89$), and smoking ($p = 0.79$). There were, however, significant association between DVA in either eye and severity of diabetic retinopathy ($p < 0.001$), macula oedema ($p = 0.02$), and hard exudates ($p < 0.001$) at baseline (Roy & Skurnick 2007: 1063-1065).

The Centre for Disease Control (CDC) analysed data from the 2002 National Health Interview Survey (NHIS) to determine the prevalence of visual impairment (VI) and selected eye diseases (diabetic retinopathy, cataracts, macular degeneration, and glaucoma) among persons aged ≥ 50 years with and without DM in the United States. The age-adjusted prevalence of VI among persons ≥ 50 years with and without DM was 23.5% and 12.4% respectively. The age-adjusted prevalence of VI was higher in women (28.5%) than in men, and higher in persons with less than high school education (30.5%) than in those with high school education and better (20.9%) (MMWR 2004).

The 1999-2004 data from the National Health and Nutrition Examination Surveys (NHANES) was analysed to estimate the prevalence and correlates of visual impairment (VI) among US adults with and without DM. The overall prevalence of presenting VI was found to be 11% and 5.9% among adults with DM and those without, respectively. After optical correction, the prevalence of VI among those with DM was 3.8% and 1.4% among those without DM. People with DM were more likely to have presenting, correctable, and

uncorrectable VI than people without DM. Uncorrectable and correctable VI was independently associated with older age, lower income, and no health insurance. People with less education, especially those with less than high school education were more likely to have uncorrectable VI than those with above high school education (Zhang, Gregg, Cheng, Thompson, Geiss, Duenas & Saaddine, 2008:1423). Findings in this study suggest that people with DM are more likely to be visually impaired than people without DM.

The 2002 National Health Interview Survey (NHIS) data was used to estimate the prevalence of self-reported visual impairment, blindness, selected eye conditions (cataract, diabetic retinopathy, glaucoma, and macular degeneration) and to characterise these conditions within a socio-demographic sub-groups, in the United States. The overall prevalence of visual impairment was found to be 9.3% and it increased from 5.7% in those between 18-44 years to 21% in those above the age of 75 years. Age was the most important predictor of visual impairment and eye diseases. The odds of having visual impairment and cataract were higher for females than males. People with low education and income were twice as likely to be visually impaired than those with higher education and income. Persons with DM were more than twice as likely to be visually impaired than those without DM. Approximately 52% of persons with diabetic retinopathy reported that they had visual impairment (Ryskulova *et al* 2008).

The centres of disease control and prevention (CDC) analysed the 1997-2010 data from the National Health Interview Survey to examine trends in the prevalence of self-reported visual impairment (VI) among people with DM (≥ 18 years old) in the United States. From 1997 to 2010, the number of adults with self-reported DM and VI increased from 2.7 million to 3.9 million ($P < 0.001$). However, the crude prevalence of people with DM and VI decreased from 26% in 1997 to 18.6% in 2010 ($p < 0.001$). The age-adjusted prevalence of VI

among the people with DM decreased from 23.7% to 16.7% ($p < 0.001$) (American Medical Association 2011).

In a study conducted in Århus county, Denmark during 1993-2002 among 7527 people with DM, the point prevalence of legal blindness among type 1 and type 2 DM patients was 0.6% and 1.5% respectively (Jeppesen & Bek 2004:528). In a study to determine the prevalence of diabetic retinopathy (DR) and causes of visual impairment among 378 type 2 DM patients in Århus county, Denmark, no patients were found to have social blindness ($VA < 6/60$), about 4% had visual impairment ($VA < 6/20$) in both eyes, of which 33% was due to diabetic retinopathy (Hove *et al* 2004:446).

One hundred and sixty four (164) ophthalmologists participated in a population-based study to investigate a broad range of predictors of vision loss among 1241 newly diagnosed type 2 patients in Denmark, the prevalence of moderate visual impairment and blindness at baseline was 5.4% and 0.9%, respectively. After 6 years, the prevalence (for 807 followed-up patients) increased to 6.7% and 2.4%, for visual impairment and blindness, respectively (de Fine Olivarius, Siersma, Almind & Nielsen 2011).

In a study conducted in Laxå community, County of Örebro, Sweden to establish a gold standard for prevention of blindness in type 2 DM populations, visual impairment was found in 10.2% of the 276 type 2 DM patients. Increasing age and lower BMI were correlated with blindness in the bivariate analyses, but in multivariate analyses, only lower BMI remained significant. Women were found to be at higher risk (2.7 times) of becoming visually impaired than men (Olafsdottir, Andersson & Stefánsson 2007:43).

In a study to assess the incidence of blindness and moderate visual impairment in diabetic patients participating in an ophthalmological control and screening programme in Helsingborg city, Sweden, the occurrence of blindness and visual impairment due to diabetic

retinopathy was higher in type 2 than in type 1 patients. At baseline there were 7 patients (1 type 1 and 6 type 2) blind ($VA \leq 6/60$) and 24 (4 type 1 and 20 type 2) visually impaired. Of the 1,769 patients included in the study, only 6 patients (all type 2) became blind and 28 (5 type 1 and 23 type 2) became visually impaired during the study. The incidence of visual impairment and blindness was significantly higher in patients with poor glucose control, older age at examination and longer duration of DM. Insulin treatment, female sex, and smoking were not significantly associated with the incidence of visual impairment and blindness (Henricsson *et al* 1996:535).

In a study conducted in the district of Rhineland, Germany between 1990 and 1991 to investigate blindness due to DM, 589 (13.5%) persons were registered as blind due to DM. The greatest numbers of persons registered as blind due to DM were found in the higher age groups (40-59 years; 60-69 years; 70-79 years;). The incidence rate of blindness due to DM in the diabetic population, standardised to the age-distribution of the diabetic population was 66 per 100,000 person years. The incidence rates were found to increase with increasing age up to the age of 79 years; however, from the age of 80 and above, the rates began to decline. In the age-groups ≥ 60 years, the incidence of blindness was statistically higher in women than in men and no cases of blindness were found in the age group below 20 years (Icks, Trautner, Haastert, Berger & Giani, 1997:572).

The prevalence of significant visual impairment related to DM and other causes in the working age population in Newcastle district, England, was determined from 130 visual impairment registrations recorded over a 5-year period (2001 to 2005). Of the 130 registration, 56 were for blindness. Among type 1 DM patients ($n=5$), 3 were blind and 2 partially sighted. Among type 2 patients ($n=15$), 5 were blind and 10 partially sighted. Among type 1 patients, proliferative diabetic retinopathy and macula oedema accounted for 60% and 40% of the registrations, respectively. In comparison,

among type 2 patients, PDR and macula oedema accounted for 40% and 60% of the registrations, respectively. Of the population at risk of visual loss from diabetic retinopathy (n=6043), the annual incidence of blindness was 0.22 per 1000 persons with DM and for partial sightedness was 0.43 per 1000 persons with DM (Arun, Al-Bermani, Stannard & Taylor, 2009:489).

The incidence of visual impairment due to diabetic retinopathy in Leeds, in 2002 was calculated based on new completed BD8 registration forms. Among the three hundred and ninety eight (398) new BD8 registrations analysed, 214 were found to be blind and 184 were partially sighted. Diabetic retinopathy was found to be the major cause of visual impairment in 24 cases (7 blindness and 17 low vision cases). For the total population, the incidence of blindness and low vision due to diabetic retinopathy in 2002 was 10 per million and 24 per million per year, respectively. For the diabetic population in Leeds, the incidence of blindness and low vision due to diabetic retinopathy was 337 and 817 per million per year, respectively (Kumar, Goyder & McKibbin 2006:456).

AL-Till *et al* (2005) investigated the prevalence of visual impairment and blindness among 986 Jordanian diabetic patients and found that the prevalence of visual impairment, severe visual impairment and blindness was 9.6%, 0.7% and 7.4%, respectively. The remaining 82.2% had normal vision. Increasing age and presence of retinopathy were significantly related to blindness. After adjustment for potential confounders, maculopathy and PDR were found to be strongly related to blindness. On the other hand, NPDR was found to have no relationship with blindness.

In a hospital-based study conducted to assess the causes of visual impairment and blindness among 694 diabetic patients in Yemen, the main causes of visual impairment were cataract (30%), clinically significant macula Oedema (CSMO) (28%), proliferative diabetic retinopathy (PDR) (17.9%), age-related macular degeneration

(ARMD) (5.1%) and glaucoma (4.4%). The main causes of blindness were cataract (29.4%), PDR (25.7%), CSMO (22%), ischaemic maculopathy (7.3%), ARMD (5.5%) and glaucoma (5.5%). Diabetic retinal complications accounted for about half of the visual impairment and blindness, 49% and 55%, respectively (Al-Akily, Bamashmus & Gunaid 2011:883).

In a population-based study in Tehran Province among 634 patients with DM in 2007, the prevalence of low vision and blindness was 6.5% and 1.6%, respectively. The prevalence of any visual impairment of VA $<6/18$ was significantly higher in patients with PDR (18.5%) than those without PDR (7%) (Javadi *et al* 2009). In a study to estimate the magnitude and risk factors of DR among 350 patients in Yemen, the prevalence of unilateral blindness ($<3/60$), bilateral blindness, and low vision ($<6/18$) was 21%, 16%, and 55.4%, respectively (Bamashmus *et al* 2009:294).

In a cross-sectional study to investigate the risk factors for low vision (VA $<6/12$ to $\geq 6/60$) and the prevalence of ischemic heart disease and nephropathy for different levels of acuities among 738 type 2 diabetic patients in Iran, the prevalence of low vision and blindness ($<6/60$) was 13.3% and 5.5%, respectively (Horri, Farmani, Ghassami, Haghighim & Amini 2011).

In a cross-sectional study to report the prevalence of visual impairment and the associated risk factors among 1414 type 2 patients in Chennai metropolis, the prevalence of visual impairment was 4%. Of this percentage, 3.6% was mild VI, 0.4% was severe VI and 0.1% was blindness (Rani *et al* 2012).

A study was conducted in Hlabisa District in the Kwazulu Natal Province to describe the diabetic population serviced by the Public Health Sector, and to assess the level of DM control as well as the extent of DM complications (Rotchford & Rotchford 2002:538). Of the 253 people with DM who participated in the study, the prevalence of severe visual loss or blindness in at least one eye was 42.8%.

Visual impairment was found in 12.3% of the subjects (Rotchford & Rotchford 2002:538).

2.7 RISK FACTORS FOR DIABETIC RETINOPATHY, VISUAL IMPAIRMENT AND BLINDNESS

Many risk factors for diabetic retinopathy, visual impairment and blindness have been reported in the above studies. Most studies found longer duration of DM to be significantly associated with the prevalence of diabetic retinopathy (DR) (Abdollahi *et al* 2006:416, Al-Maskari *et al* 2007, Bamashmus *et al* 2009:294, Carmichael *et al* 2005:57, Krishnaiah *et al* 2007:478, Javadi *et al* 2009, Wang *et al* 2011:e339, Kim *et al* 2011:1070, Rotchford & Rotchford 2002:538, Rotimi *et al* 2003:112). In some studies, longer duration of DM was found to be a significant risk factor for the incidence and progression of diabetic retinopathy (Fong *et al* 2003:s99, Klein *et al* 1989:246a, Klein *et al* 1994:1217). However, in some studies, longer duration of DM was not a significant risk factor for the incidence and progression of DR (Grauslund *et al* 2009:1831, McCarty *et al* 2003:399, Varma *et al* 2010). Longer duration of DM was found to be associated with visual impairment (Horri *et al* 2011).

Some studies found increasing age to be significantly associated with the prevalence of DR (The Eye Diseases Prevalence Research Group 2004:556, Abdollahi *et al* 2006:416, Al-Maskari *et al* 2007, Krishnaiah *et al* 2007:478, Rotchford *et al* 2002: 538, Ryskulova *et al* 2008, Shaik *et al* 2008:777). However, other studies did not find a significant association between age and the prevalence of diabetic retinopathy (Javadi *et al* 2009, Bamashmus *et al* 2009:294, Hove *et al* 2004: 446, Rani *et al* 2009).

In studies that investigated the prevalence of visual impairment and blindness, increasing age was found to be significantly associated with the prevalence of visual impairment and blindness (Horri *et al* 2011, Rani *et al* 2012, Roy 2000:102, Roy 2007, Ryskulova *et al*

2008, Saaddine *et al* 1999:1201). In addition, increasing age was found to be a significant risk factor for the incidence of visual impairment and blindness (Henricsson *et al* 1996:535, Icks *et al* 1997:572, Olafsdottir *et al* 2007:13).

In studies that examined DM treatment as a risk factor, insulin treatment was found to be significantly associated with the prevalence of DR (American Medical association 2010, Bamashmus *et al* 2009:294, Hove *et al* 2004:446, Javadi *et al* 2009, Klein *et al* 1983: 233, Narendran *et al* 2002:1016, Rani *et al* 2009, Wang *et al* 2011: e339,). In contrast, other studies found no significant association between insulin treatment and DR prevalence (McCarty *et al* 2003:399, Klein *et al* 1984:524). In recent study, insulin treatment was also found to be associated with visual impairment (Rani *et al* 2012)

High glycosylated haemoglobin (HbA1c) was found to be significantly associated with the prevalence of diabetic retinopathy (Abdollahi *et al* 2006:416, American Medical Association 2010, Grauslund *et al* 2009, Kim *et al* 2011:1070, Klein *et al* 1984:524). Male gender was found to be significantly associated with diabetic retinopathy (Al-Maskari *et al* 2007, Hove *et al* 2004:446, Javadi *et al* 2009, Stratton *et al* 2001:158). In contrast, Rotchford & Rotchford 2002:538 found female gender to be significantly associated with diabetic retinopathy.

Some studies revealed that females were at higher risk of visual impairment and blindness than males (MMWR 2004, Roy 2000: 102, Rani *et al* 2012, Ryskulova *et al* 2008, Saaddine *et al* 1999:1201). In contrast, female sex was insignificantly associated with visual impairment in another study (Henricsson *et al* 1996:535). The type of DM was also found to be associated with visual impairment and blindness. The prevalence of visual impairment was found to be higher in type 2 than type 1 DM patients (Henricsson *et al* 1996:535, Arun *et al* 2009:489, Jeppensen & Bek 2004:528). This is probably

because there are more patients with type 2 than there were type 1 patients. In addition, in most cases, type 2 patients are generally older than type 1 patients, which suggest that the age- related causes (cataract, glaucoma, stroke, etc) of visual impairment and blindness may be more prevalent among type 2 patients compared to type1 patients.

Other risk factors that were found to be significantly associated with DR include high systolic blood pressure, hypertension, nephropathy, socioeconomic status, body mass index (BMI) (Abdollahi *et al* 2006:416, Horri *et al* 2011, Krishnaiah *et al* 2007:478, Rani *et al* 2009, Elshazy 2010:6235). Socioeconomic factors such as the low level of education, unemployment, low income were found to be significantly associated with the prevalence of visual impairment and blindness (MMWR 2004, Ryskulova *et al* 2008, Saaddine *et al* 1999:1201, Zhang *et al* 2008:1423).

2.8 CAUSES OF VISUAL IMPAIRMENT AND BLINDNESS AMONG PEOPLE WITH DIABETES MELLITUS

Diabetic retinopathy was found to be major cause of visual impairment and blindness in persons with DM (Henricsson *et al* 1996:535, Hove *et al* 2004:446, Jeppensen & Bek 2004:528, Kumar *et al* 2006:456, Roy 2000:102). However, in some studies it was found to be the second most common cause of visual impairment and blindness (Arun *et al* 2009: 489, de Fine Olivarius *et al* 2011). Some studies identified cataract as the major cause of visual impairment and blindness (Read & Cook 2007: 61, Rotchford & Rotchford 2002:528). Other causes of visual impairment and blindness that have been identified include age-related macular degeneration, diabetic maculopathy, glaucoma, refractive errors, optic atrophy and stroke (de Fine Olivarius *et al* 2011, Hove *et al* 2004:446, Jeppensen & Bek 2004:528, Read *et al* 2007: 61, Rotchford & Rotchford 2002:528)

2.9 CONCLUSION

This chapter reviewed literature on the historical overview of visual impairment and blindness and the earlier programmes that were initiated to eliminate blindness from preventable causes. The global prevalence, causes, distribution and cost of visual impairment were discussed. The number of people becoming blind due to trachoma, onchocerciasis and vitamin-A deficiency has decreased in the past decades. This may be attributed to the improvement in the socioeconomic development and medical technology in the past two decades. However, this improvement in medical technology implies that many people will live longer and therefore suffer from age-related conditions, such as cataract, glaucoma, diabetic retinopathy, and age-related macular degeneration, which are significant causes of visual impairment and blindness.

The definitions, new classification and epidemiology of DM were also outlined in this chapter. The clinical features of non-proliferative diabetic retinopathy, proliferative diabetic retinopathy and diabetic maculopathy were described and various classifications of DR were tabulated. A historical overview of the diabetic retinopathy studies, which includes the Wisconsin Epidemiological Study of Diabetic Retinopathy (WESDR), Diabetes Control and Complications Trial (DCCT), United Kingdom Prospective Diabetes Study (UKPDS) and the Early Treatment of Diabetic Retinopathy Study (ETDRS) was discussed. The prevalence, incidence and progression of diabetic retinopathy (DR) and visual impairment were also discussed.

The Wisconsin Epidemiological Study of Diabetic Retinopathy (WESDR) found the prevalence of DR to range from 21% in those with <5 years duration of DM to 97.5% in those with ≥ 15 years. The Diabetes Control and Complications Trial (DCCT) reported the prevalence of 54.1% in those with <5 years duration and the United Kingdom Prospective Diabetes Study (UKPDS) reported the prevalence of 37% (Klein *et al* 1983:233, Malone *et al* 2001:523,

Stratton *et al* 2001:158). The prevalence in these “gold standard” studies was found to be higher than those found in those found in the other studies. For instance, in the developed countries, the lowest prevalence of DR (3.4%) was reported in the US (The EDPRG 2004:556) and the highest prevalence for DR (97%) was reported in Denmark (Grauslund *et al* 2009:181). In developing countries the lowest prevalence of any DR (7.9%) was reported in Oman (Khandekar *et al* 2009:676) and the highest was reported in Egypt (69%) (Elshazly *et al* 2010:6235). One of the reasons for differences may be the fact that DM management has improved since the earlier studies were done in the 1980’s. In addition, the variation in the prevalence of DR in the different countries is due to a variety of reasons, such as the methodology used, demographic characteristics of the samples, etc.

The risk factors for diabetic retinopathy and visual impairment and blindness as well as the causes of visual impairment and blindness were discussed. Almost all of the reviewed studies identified longer duration of DM as a significant risk factor for diabetic retinopathy. Females, low level of education, unemployment, low household income have been found to be significantly associated with increased prevalence of visual impairment and blindness. Diabetic retinopathy was found to be a major cause of visual impairment and blindness in the developed countries, while in developing countries cataract was found to be the major cause.

CHAPTER 3

CONCEPTUAL FRAMEWORK

3.1 INTRODUCTION

The preceding chapter reviewed literature on the historical overview of visual impairment and blindness, an overview of diabetic mellitus (DM), historical overview of DR studies, prevalence and incidence as well as causes of VI and blindness among people of diabetes mellitus.

This chapter begins by outlining the risk factors for visual impairment and blindness and the conceptual framework as well as the possible levels of interventions to prevent visual impairment and blindness. The concept of health promotion and some of its components, which include health education, advocacy for prevention of blindness, advocacy for the rights of people with visual impairment and blindness, and advocacy to address the exclusion of persons with visual impairment and blindness, are also outlined.

Research reports have shown that the average time spent from a state of no diabetic retinopathy to background retinopathy and blindness is approximately 10 years and 23 years, respectively. In addition, it has been reported that early detection and treatment of diabetic retinopathy may lead to 60% reduction in DR progression from PPDR to PDR, and 57% reduction in the progression from PDR to blindness (Liu *et al* 2003:729). This indicates that the prevalence of visual impairment and blindness due to DM can be minimised, if the risk factors of DM and diabetic retinopathy are identified early and proper interventions implemented.

3.2 THE RISK FACTORS FOR VISUAL IMPAIRMENT AND BLINDNESS IN PERSONS WITH DIABETES MELLITUS

Several authors have identified various risk factors that are associated with visual impairment and blindness in persons with DM. The factors that were found to be associated with visual impairment and blindness include increasing age, gender, type of DM, low level of education, unemployment, and low income (Zhang *et al* 2008:1423, Ryskulova *et al* 2008, Arun *et al* 2009:489) (Details are discussed in chapter 2). Risk factors that were assessed in this study were categorised into socio-demographic, anthropometric and clinical risk factors (see details in Figure 3.1).

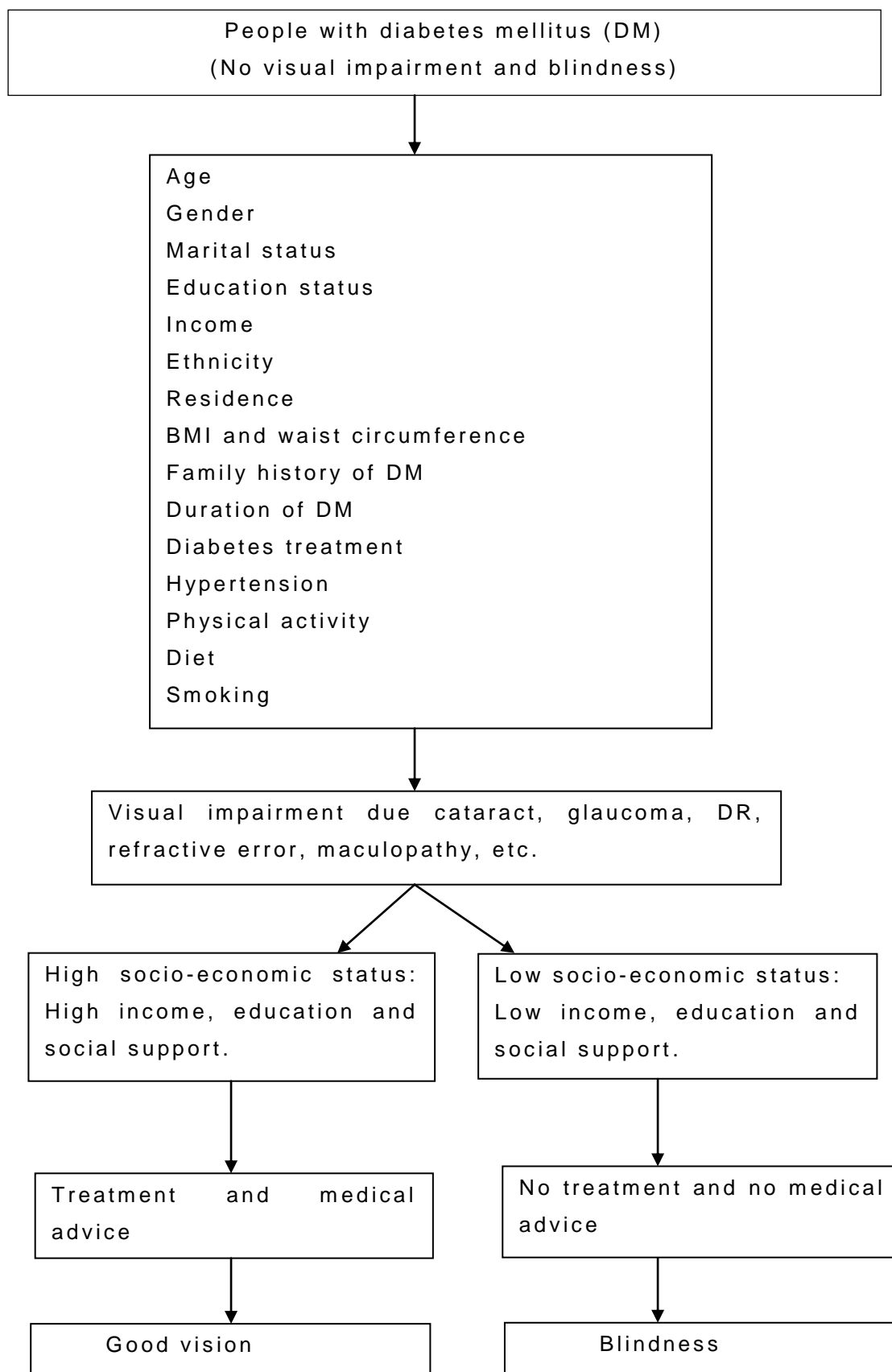


Figure 3.1. Conceptual framework flow diagram

The above framework explains the relationship between the various risk factors and visual impairment and blindness among people with diabetes. Increasing age, female gender, low socio-economic status, residence, obesity, family history of DM (parent or siblings), longer duration of DM, DM treatment (especially insulin injection), smoking, physical inactivity and unhealthy diet have been found to be associated with visual impairment and blindness. Generally, as people age, their vision gets impaired due to various causes including cataract, glaucoma, diabetic retinopathy etc. If untreated, these conditions may lead to blindness.

People with high socio-economic status have better access to eye care services and can therefore get treatment and medical advises to prevent avoidable visual impairment and blindness. Those with low economic status are likely to get blind due to lack of access to eye care services. Many eye care providers (optometrists and ophthalmologists) are often concentrated in the urban areas. This suggests that people living in the rural areas are likely to become blind due to lack of eye care services, while those in the urban areas can access eye care services and restore their vision or prevent blindness. Family history of diabetes (parent or siblings), physical inactivity and unhealthy diet may lead to overweight/obesity, poor high blood pressure and glucose control, which may lead to diabetic retinopathy and its progression and eventually blindness. Smokers have been found to have higher prevalence of visual impairment than non-smokers do. Insulin users are more likely to have visual impairment than non-insulin users.

3.3 THE POSSIBLE LEVELS OF INTERVENTIONS TO PREVENT VISUAL IMPAIRMENT AND BLINDNESS AMONG PERSONS WITH DIABETES MELLITUS

According to Katzenellenbogen *et al* (1997:14), the common approach to disease prevention is divided into four parts, representing all levels of intervention, where applicable. The four levels of intervention include primordial, primary, secondary and tertiary prevention (Table 3.1). The researcher has used these four levels of intervention to formulate the possible levels of interventions to prevent visual impairment and blindness among persons with DM.

3.3.1 Primordial prevention

This level aims to curb the development of unhealthy lifestyle patterns among groups or populations that have not yet developed these unhealthy patterns (Katzenellenbogen *et al* 1997:14). Since the present study focuses on diabetes-related visual impairment and blindness, this level therefore aims to discourage the development of unhealthy lifestyles that increases the risk of DM. South Africa is one of the countries in Africa that has adopted the Western style of living, which include unhealthy diet and physical inactivity.

Anecdotal evidence suggests that most communities in South Africa consume diet with higher content of salt, fat and processed sugars. Additionally, most people tend to engage in less aerobic exercises. This may be attributed to the increased availability of public transport and cars that people use even for short distances and thus walk less. Studies have shown that type 2 DM can be prevented by lifestyle changes of persons at risk of DM (The Finish diabetes prevention study group 2001:1348, Centres for disease control and prevention 2012). Preventing or reducing the incidence of DM would result in prevention or reduction in diabetes-related visual impairment and blindness. It is therefore recommended that policy

makers should formulate health policies that encourage health promotion that will reduce the risk of chronic diseases of lifestyle, including DM.

3.3.2 Primary prevention

This level is targeted at healthy people, individuals or groups. At this level, measures are taken to promote optimum health or provide specific protection of target groups against disease and injury. This can be done on a non-personal level where the risk factor is removed or on a personal level by vaccination, where applicable (Katzenellenbogen *et al* (1997:14). The DCCT has demonstrated that proper BP control and proper glucose control reduces the incidence and progression of DR among persons with diabetes (Fong *et al* 2003:599, Klein *et al* 1984:524). Therefore, people should be encouraged to take measures that would ensure that their blood glucose level and blood pressure are always normal. The measures may include regular visits to health facilities to have their BP and glucose level checked; physical activities, healthy diet and weight loss.

3.3.3 Secondary prevention

This level is aimed at people who have the disease that has not yet produced symptoms. Prevention measures at this level include early diagnosis and prompt treatment to prevent development of disease complications (Katzenellenbogen *et al* 1997:14, WHO 2004:47). Diabetic retinopathy has few visual symptoms until visual loss develops. Secondary prevention would therefore involve early detection of diabetic retinopathy lesions and treatment through photocoagulation where indicated to prevent visual loss. Early detection of diabetic retinopathy can be achieved through routine screening for diabetic retinopathy. It is recommended that type 1 DM patients should have the first Dilated Fundus Examination (DFE) within 3-5 years after diagnosis of DM once the patient is 10 years

or older. For type 2 DM patients, the first DFE should be done at the time of diagnosis of DM. Thereafter, DFE should be done annually in both type 1 and type 2 DM patients (Fong *et al* 2003: s101)

3.3.4 Tertiary prevention

This level involves the treatment of the disease at its later stages and rehabilitation to optimise function, thus limiting the negative effects of an established disease (Katzenellenbogen *et al* 1997:14, WHO 2004a :47) In the case of diabetic retinopathy, tertiary prevention involves treatment of the severe vision threatening diabetic retinopathy and clinical significant macula oedema in order to prevent blindness. Measures taken at this level include scatter (pan-retinal) photocoagulation and early vitrectomy on all eyes with severe sight-threatening DR. The ETDRS reported a statistically significant reduction in severe vision loss in all eyes (with severe NPDR or early PDR) treated with early scatter photocoagulation. Reduction in vision loss was also reported in eyes with CSMO that were treated with focal photocoagulation (Davis *et al* 1998:244). Cataract surgery should also be performed on those with cataracts. Patients should be referred to low vision specialists for rehabilitation to optimise function.

Table 3.1: Possible levels of interventions to prevent visual impairment and blindness among persons with diabetes mellitus

Primordial and primary prevention

Key area of action: Reducing the risk of DM and its complications

Action	Actions
Health promotion; raising public awareness Target group: Population at risk of DM	Health education about the risk factors of DM, emphasise importance of healthy lifestyles, proper control & monitoring of BP and blood glucose

Secondary prevention

Key area of action: Increasing early detection of diabetic diseases

Action	Actions
Health promotion; public awareness & capacity building Target group: People with DM with undiagnosed DR and eye care providers	Promote awareness about the need for regular eye examination, capacitate eye care providers to detect & monitor diabetic eye diseases

Tertiary prevention

Key area of action: Improving access to eye care services

Action	Actions
Raising awareness Target group: People with DM with PDR, CSMO, cataract and glaucoma & eye care providers	Promote awareness about availability of services such as photocoagulation, vitrectomy, cataract surgery, and glaucoma treatment. Encourage referral to relevant institution.
Eye care professional supply. Target population: health department	Address shortage of eye care professionals; manage distribution of the professionals; provide incentives for professionals to work in rural areas.
Affordability and accessibility Target population: health department	Low vision & rehabilitation services to be made affordable and accessible to those in need of the services

3.4 HEALTH PROMOTION

According to the WHO (1986), health promotion is the process of empowering people to make healthy lifestyle choices and motivating them to increase control over their own health. Health promotion enables an individual or group to identify and to realise aspirations, to satisfy needs, and to change or cope with the environment. Therefore, health, which is a state of complete physical, mental and social well-being, is seen as a resource for everyday life, not just an objective for living. Consequently, health promotion cannot be the responsibility of the health sector alone, but should go beyond healthy lifestyles to well-being. The concept of health promotion was first elaborated in 1986 in the Ottawa charter, which set out five areas of activity (WHO 1986). The five key areas of activity include:

- i. Building healthy public policy
- ii. Creating supportive environment
- iii. Strengthening community action
- iv. Developing personal skills
- v. Reorienting health services

Subsequent to the Ottawa Charter, several international conferences and meetings further clarified the relevance and meaning of the key strategies in health promotion. The 4th international conference on health promotion was held in Jakarta in 1997. This was the first conference to be held in a developing country and the first to involve the private sector in supporting health promotion. It has provided an opportunity to reflect on what has been learned about effective health promotion and to identify strategies that must be adopted to address challenges of promoting health in the 21st century. The Jakarta declaration on health promotion into the 21st century states that there is now clear evidence that:

a) Comprehensive approaches to health development that are the most effective are those, which use the combinations of the above five strategies rather than single-track approaches.

b) Particular settings that offer practical opportunities for the implementation of comprehensive strategies include mega-cities, islands, cities, municipalities, local communities, markets, schools, the workplace, and health care facilities.

c) Participation is essential to sustain efforts, which means that people have to be at the centre of health promotion action and decision-making process for it to be effective.

d) Health education fosters participation, which means that people and communities need to be educated and well informed to achieve effective participation.

The above strategies are core elements of health promotion and are relevant for all countries (WHO 1997).

3.4.1 Components of health promotion

3.4.1.1 *Health education*

Health education is one of the components of health promotion that has been predominant in many countries. In many developing countries where resources and training are scarce, health education has been shown to have limited impact on changing behaviour. This is probably because health education was often didactic, culturally inappropriate and victim blaming (Coulson [s.a]:290). For health educational programmes to be effective, two important requirements need to be fulfilled. These include understanding the underlying influences on behaviour, and the selection of the appropriate methods, target groups, and settings for the educational programmes (Hubley & Gilbert 2006:279). In this study, health

education would focus on promoting the adoption of eye health promoting behaviours and an increase in the uptake of available eye care services.

a) The importance of human behaviour

Human behaviour plays a very important role in the prevention of blindness. This is because people are the ones who need to adopt eye health promoting behaviours and avoid behaviours that may lead to vision loss. The role of human behaviour and the scope of blindness prevention would obviously depend on a specific condition. There are many conditions such as trachoma, sexually transmitted diseases, eye injuries, and to some extent type 2 DM that have enough scope for primary prevention (Hubley & Gilbert 2006:279). People at risk of these conditions can prevent blindness through adoption of appropriate lifestyles. The occurrence of a condition such as cataract may be delayed by avoiding excessive exposure to sunlight and wearing sunglasses with UV light protection. Although, condition such as glaucoma cannot be prevented, early detection and treatment can prevent visual impairment. Success of the intervention programmes will depend on the willingness of the individuals and communities to modify their behaviour or to take up the eye care services (Hubley & Gilbert 2006:279).

Health promotion studies have been carried out to establish the reasons why people do not engage in activities that promote eye health, such as regular eye examinations, glaucoma screening, diabetic retinopathy screening, cataract surgery, etc. In those studies, people cited a number of barriers that prevent them from taking up eye services. Availability, accessibility, and affordability and other factors were cited as barriers to people's engagement in eye health care promotion (Hubley & Gilbert 2006:279) (Discussed in detail in Chapter 1). Any barriers that prevent people from engaging

in eye health promotion should be identified and addressed by relevant eye care authorities.

Since this study focuses on diabetes-related visual impairment, people should be encouraged to adopt behaviours that would help minimise the risk of DM; those who already have the disease should be encouraged to adopt behaviours that would prevent or minimise the incidence of DM complications, including diabetic retinopathy.

In order for people to exercise more control over their own health and to make choices conducive to health, they need to be provided with relevant information, health education and life skills. For purposes of eye health, health education is aimed at promoting the adoption of eye health promoting behaviours and increasing the uptake of eye care services. Persons with DM should be given information about diabetic retinopathy (DR) and its impact on vision. People need to be informed about the risk factors of DR and what they can do to eliminate or minimise the effect of the risk factors and the available treatment options. For instance, people should be encouraged to adopt behaviours that would help to keep their BP and blood glucose level normal to prevent the incidence of DR. People with cataract and glaucoma should be informed about the availability of services for cataract and glaucoma management to preserve their vision.

b) Health education approaches

Since people vary in their socio-economic conditions, traditions, attitudes, beliefs, and level of knowledge about DM and diabetic retinopathy, uniform communication approach may not be viable. Depending of the local circumstances, a combination of different approaches must be developed to educate the target population about these conditions. The approaches are classified into mass approach, group approach and individual approach. As their names suggest, the main difference between these approaches is the

number of people they are intended to reach. For the education campaign to be effective, all three approaches must be used to varying degrees (Kaliyaperumal 2004:13).

i. Mass approach

The mass approach is intended to reach a large number of people at a low cost per person reached. The main goal of this approach is to create awareness and increase the level of knowledge about a particular problem, in this case, DM and diabetic retinopathy (Kaliyaperumal 2004:13). Mass approach can be delivered through different media, including the following:

a) Mass media, such as television, newspapers, and radio can be used to effectively increase the level of knowledge in the community about DM and diabetic retinopathy. The benefits of television and radio announcements in creating awareness of the problem are that people with visual impairment and those who cannot read can hear them. The disadvantage of television and radio announcements is that it is likely to be more expensive to convey more the information about a particular problem (Kaliyaperumal 2004:13).

b) Poster display in hospitals or public meeting places- posters carrying information about DM and diabetic retinopathy can be displayed in eye hospitals, diabetes clinics and public meeting places. The disadvantage of poster display is that information may not be clearly transmitted to the illiterate and the visual impaired. However, for the literate and those who can see well, this medium is appropriate, as people who need it most would see the information (Kaliyaperumal 2004:13).

c) Pamphlets and booklets may be distributed in the community to provide in-depth information about diabetic retinopathy and its risk factors and treatment options. This is an advantage over television

and radio, which only provide basic knowledge due to the cost involved.

d) Exhibition and local fairs or festivals- these media provide an opportunity to reach a large audience using booth distributing information, education, and communication (IEC) materials. The advantage of these media is the possibility of the public interacting with people who can provide more clarification on the information contained in the materials (Kaliyaperumal 2004:14).

ii. Group approach

This approach is intended to reach smaller groups of the target population who have some basic knowledge about DM and diabetic retinopathy. This approach is designed to change the attitudes and opinions that the target group may have about DM and diabetic retinopathy. The intention is to have audience for a sustained period of time where they can ask questions and get answers same time from knowledgeable people. This is advantage over mass media where people do not have an opportunity to ask questions. The group approach can take the form of group discussion, guest lecturers and health education training sessions (Kaliyaperumal 2004:13).

iii. Individual approach

This is the most effective approach to change people's attitudes and opinions about DM and diabetic retinopathy. This is because in this approach there is greater interaction between the health educator and the targeted individual, when compared to the mass approach and the group approach. The disadvantage of this approach is that it is costly and time consuming. This approach may take the form of door-to-door home visits and counselling during eye screening or examinations (Kaliyaperumal 2004:13).

It is clear from the above discussion that the mass approach and the interpersonal approach have individual and complimentary roles. As indicated above, mass communication provides some basic information about DM and diabetic retinopathy. On the other hand, interpersonal communication provides deeper understanding of DM and diabetes retinopathy. Therefore, before health education programmes could be rolled out, it would be necessary to first establish the media that are available and accessible to the target population. It is generally accepted that mass media are particularly acceptable when the behaviour changes to be promoted are simple and there are no barriers to the community engaging in the action. However, when the behaviours to be changed are deeply rooted in cultural beliefs, then mass media need to be supplemented by face-to-face communication (Hubley & Gilbert, 2006:281).

c) Choice of setting for health education

The choice of a setting for health education is important for an effective health education. Community groups, schools, churches, health facilities are among the many settings available for use in health education. Generally, people's behaviours are influenced by culture, tradition, economics, and power; and all these operate at the community level. Therefore, if a community is chosen as a setting for an education programme, then community members need to be involved in decision making on matters concerning their health. This is necessary for community-based programme to succeed. If community members are not involved, there is a chance that people may not cooperate in the health promotion activity. In a study conducted in the late 1970's in Gazankulu (now part of Limpopo Province), South Africa, the community-based approaches using volunteers and community groups were found to have some influence on eye health knowledge and on the incidence of trachoma. The study also revealed that eye health can be a starting point for involving communities in addressing a wide range of other social and health issues (Hubley & Gilbert 2006:281).

Schools have a greater potential for blindness prevention programmes, precisely because pupils and teachers are very much aware of the benefits of good vision on learning. It would therefore be easy for schools to adopt any behaviour that would prevent blindness. In addition, pupils always take what they learned at school home (Hubley & Gilbert 2006:281). This suggests that even though the health education is implemented at school, parents and siblings with a child in the school are likely to benefit from the health promotion activity.

Health facilities are also another setting for health education programmes. People visiting the health facilities can be given information on various health topics at the Out Patient Department (OPD) while waiting for the doctor. People who visit the health facilities on a monthly basis to collect medication for chronic diseases can also be given information on their condition and associated conditions. For instance, people attending diabetes clinic within the hospital, can be given information on hypertension, diabetes, diabetic retinopathy, glaucoma and cataracts.

3.4.1.2 Health services improvement

It is important that health education and health services improvement take place alongside each other. Improvement should address locally identified barriers to uptake of services, which may include accessibility, affordability, acceptability and whether the services are effective or not (Hubley & Gilbert 2006:282). Persons with DM may require diabetic retinopathy screening, photocoagulation, cataract operation, and glaucoma screening and treatment. There is therefore a need to have more eye health personnel and health facilities that offer the above services. The issue of shortage of staff and long queues should be addressed as this can be a barrier in the uptake of services. There is a need to

improve the skills of more eye care professionals in the early detection of DR, glaucoma and cataract.

3.4.2 Advocacy

Advocacy is an act of arguing on behalf of a particular issue, so that it gets the attention it deserves, or on behalf of particular groups of people (usually the vulnerable or disadvantaged), so that their voices are heard and their interest are taken into account (Prozesky 2007:57).

3.4.2.1 Advocacy for the prevention of visual impairment and blindness

People with DM are at risk of visual impairment and blindness, and are therefore vulnerable; and those who are already visually impaired due to DM are disadvantaged. Therefore, there is a need for advocacy to persuade those in authority or those with influence to use their authority to promote actions that would help to prevent diabetes-related visual impairment. According to Prozesky (2007:57), there are several reasons why advocacy in eye health is needed; and they include the following:

- i. Advocacy is needed to raise awareness concerning the patients' needs, which may lead to improved eye care services. The eye care providers should act as advocates in this regard.
- ii. Advocacy can raise public awareness of eye problems and their impact on quality of life of the affected persons. For example, very few people are aware that DM is the number one cause of blindness among adults of working age; and that blindness has serious socio-economic impact on the affected individuals, their families and society in general. If people are aware of these facts, they are likely to participate in the eye health promotion activities and to pressurise authorities to allocate sufficient resources to eye care.

- iii. Advocacy can help organisations representing the visually impaired to gain access to necessary resources needed for the improvement of eye care services.
- iv. Advocacy can be used to influence policies, which affect how resources are allocated. Through advocacy, policy makers can be influenced to allocate resources for prevention of eye diseases, eye health promotion, and eye care services.
- v. Before advocacy can be initiated, there is a need to identify those groups of people who are in a position to make important decisions that have direct impact on eye care delivery or those who just have an influence on others in a way that will improve the delivery of eye care.

a) The key target groups for advocacy

The key target groups must be made to realise the benefits of what is being advocated so that it can be easier for them to have sustainable support for such initiatives. In the case of persons with DM, the target groups must be able to appreciate the benefits of prevention of type 2 DM; the benefits of early detection and treatment of diabetic retinopathy and glaucoma; and the benefits of cataract operation. Thulasiraj (2007:66) identified the following groups as key target groups for advocacy:

i. Policy makers (Government)

Policy makers are in a position to create and implement policies and regulations, and should be targeted by those advocating for better eye care delivery. The advocacy messages targeting policy makers should focus on the positive impact of the initiative on the people receiving the messages. In addition, the initiative should reflect well on the policy makers themselves (Thulasiraj 2007:66). In the case of diabetes-related visual impairment, policy makers to be targeted are those in the health department, labour department as they are in the

position to improve access to eye care. For example, they can encourage people to eat healthy diet and to engage in physical activities to reduce the risk of chronic diseases of lifestyle, including type 2 DM. This will in turn reduce the risk of diabetic retinopathy and the resulting visual impairment. They can encourage diabetic retinopathy and glaucoma screening (for early detection of these conditions); they can also encourage those with sight-threatening retinopathy and cataract to go for photocoagulation and cataract operation, respectively, to prevent blindness.

The economic costs of DM are enormous. In the US alone, DM is responsible for 116 billion dollars in medical costs, as well as 58 billion in reduced productivity from work-related absenteeism, reduced productivity at work and at home from chronic disability and premature mortality (American Diabetic Association 2008:604). Diabetes mellitus also imposes intangible costs in society in terms of reduced quality of life and the pain and suffering of people with DM, their family and their friends (American Diabetic Association 2008:604). It has been shown that early detection and treatment of diabetic eye diseases provides a substantial federal budgetary savings and has also been found to be a highly cost-effective investment for the society (Javitt & Aiello 1996: 166). Therefore, advocacy can focus on the positive impact that these services will have on the health budget, the country's economy and the quality of life of the persons with DM.

ii. Community leaders

Generally, the community elects community leaders who are people who have the interest of the community and the community appreciates their leadership. These individuals should be targeted for advocacy for eye care programmes as they have significant influence on the community. For community-based programmes such as health education, eye screenings *etc* to be successful, and these leaders need to be persuaded to support these initiatives.

Advocacy targeting community leaders needs to focus on the magnitude and impact of diabetes-related visual impairment, as well as on the risk factors, treatment options, costs and benefits. The leaders must be made to understand that DM is the number one cause of blindness among economically active adults in many countries, and that in South Africa it is the third common cause of blindness after cataract and glaucoma; which are also more common among persons with DM. The leaders must be informed that proper control of BP and glucose level can reduce the incidence of DR and visual impairment. They must also be informed that early detection (through screening) and treatment of DR (through photocoagulation) can reduce the incidence of low vision and blindness. Once the community leaders understand all of the above benefits, they can therefore support the promotion of eye care in the community.

iii. Health professionals

Several health professionals, including general practitioners, pharmacists, nurses, dieticians etc. have access to persons known to have diabetes. Unfortunately, there is some anecdotal evidence to suggest that some of these health professionals are unaware of DR and of its treatment options. Health professionals should therefore be targeted for advocacy; they should be informed about the important role they can play in preventing diabetes-related visual impairment. Advocacy can also be directed towards medical training institutions to convince them to include diagnosis and treatment of DR in their curricula, as well as patient counselling and remote diagnostic techniques. Successful advocacy targeted to health professionals can result in an increase in the number of patients seeking DR services, better referral to treatment and follow-up, and a reduction in the number of patients presenting with sight-threatening DR (Thulasiraj 2007:67).

Optometrists and ophthalmologists should primarily be targeted for advocacy to improve low vision and rehabilitation services. Patients with low vision and blindness often come into contact with these professionals, but they are not referred for low vision and rehabilitation services. These professionals need to be encouraged to refer low vision patients to low vision specialists and blind people to rehabilitation centres. Successful advocacy can result in rehabilitation services that reach more people with low vision and blindness.

3.4.2.2 Advocacy for the rights of people with visual impairment and blindness

The above discussion focused mainly on eye health promotion that would help in the prevention of diabetes-related visual impairment. However, there are situations where individuals are already visually impaired from diabetes. There is therefore a need for advocacy programmes aimed at addressing the plight of these individuals. Visually impaired individuals face significant barriers to full participation in society. In addition, unless such barriers are overcome, the visually impaired individuals will be excluded from full participation in society.

Barriers that visually impaired individuals face include poor access to information; poor access to public premises, services and environment; high levels of unemployment, among others. These barriers make these persons feel powerless and useless in society, as they have to depend on other people to survive.

According to Daye (2005), the barriers experienced by the visually impaired are centred on the following two themes: (a) the direct and indirect result of severe visual impairment (i.e. factors arising from the vision impairment itself and access issues), and (b) ignorance and discrimination on the part of the society.

a) Barriers experienced as a direct and indirect result of visual impairment and blindness

Barriers related to visual impairment and blindness itself and access issues include the following:

i. Poor access to information

Most of the information regarding community services, health services, employment opportunities, etc., is mostly disseminated via print media, such as newspaper advertisements, bulletins, brochures and posters in community centres, in hospitals and government offices. This implies that the visually impaired persons would not be able to access the information on for example; diabetes and diabetic retinopathy; availability of low vision and rehabilitation services, etc, as they cannot read printed material. In addition, visually impaired people with DM may need to read the labels on their tablets and to monitor glucose level by themselves, but they cannot do it because the information is only available in printed format. Lack of independent access to information creates an unnecessary dependence on others, compromises privacy and dignity, and most importantly puts the health of the visually impaired persons in jeopardy (Blind Citizens Australia [s.a]). There is therefore a need to advocate for the information to be made available in alternative formats that are accessible to the visually impaired persons.

According to the South African constitution, access to information is a right that should be enjoyed by all South Africans, including those with visual impairment. Therefore, it is against the law to deny them access to information. People advocating for the visually impaired should be made aware of this fact.

ii. Poor access to premises and services

Most premises, including community centres, government offices, healthcare facilities, workplaces *etc* are generally not accessible to persons with visual impairment. Persons responsible for these settings should be informed about the plight and the rights of the visually impaired and what they can do to improve the situation. For example, these settings can be made accessible by installation of better lighting, appropriate signage, and the use of tactile and auditory cues, especially as hazard markers and way-finding devices (Blind Citizens Australia [s.a]).

Persons with visual impairment also face issues related to access to jobs and various services, including health services. Persons who become visual impaired while in employment may find it difficult or impossible to continue doing their jobs. This may cause them to opt for early retirement, which may have a negative impact on their lives and that of their families. Employers should be encourage through advocacy to initiate programmes to re-train people who become visually impaired during employment, and/or provide low vision aids to those who can benefit from them. Sometimes the barriers to access to services experienced by the visually impaired persons emanate from the lack of knowledge on how to interact with the visually impaired on the part of the staff. There is therefore a need to advocate for the introduction of basic training for the staff servicing persons with visual impairment.

b) Barriers related to ignorance and discrimination on the part of the society.

Most sighted persons are ignorant of the capabilities of persons who are visually impaired; they believe that visually impaired persons are unsafe or are not as capable as they actually are. Persons with visual impairment or any other disability are regarded as being

stubborn and good for nothing. Consequently, they are not included in family matters, in decision-making, community development programmes and are even denied access to basic services such as education and social life. In Sierra Leone, the society believes that any achievements by visually impaired persons have been realised through the help from evil's spirits. The society have a saying that says, "A blind person can only succeed if those who are sighted agree" (Sesay [s.a]: 3). There is therefore a need for campaigns to educate the society that visually impaired persons are human beings who also have capabilities that can benefit the community and society at large.

In South Africa, the majority of persons with disability, including the visually impaired have been excluded from the mainstream of society and have thus been denied access to basic social, political and economic rights. This has been due to a range of factors such as the political and inequalities of the apartheid system, discriminatory legislative framework that sanctioned and reinforced exclusionary barriers; and the attitudes and beliefs of society that visually impaired persons are dependent and in need of care (South Africa 1997).

After the end of Apartheid in 1994, the Republic of South Africa adopted a new constitution, new Acts, policies and programmes aimed at empowering historically disadvantaged individuals, including blind people. The constitution of South Africa, Act 108 of 1996 explicitly prohibits unfair discrimination by the state or any person directly or indirectly based on disability, among other grounds. The law further states that all South Africans are equal before the law and that equality includes full and equal enjoyment of all rights and freedoms.

Despite the existence of good laws and policies in South Africa, the majority of persons with visual impairment still do not receive basic rehabilitation services and are not enabled to participate equally in

education, training, employment, recreation or other activities in their community or in wider society. This implies that persons with visual impairment do not fully enjoy their rights as enshrined in the constitution. This is because some new laws and amendments contain sections that directly or indirectly lead to discrimination against people with disabilities. Consequently, large sections of the legislative framework in South Africa do not meet international human rights standards and principles with regard to the rights of people with disabilities (South Africa 1997). There is therefore a need to intensify the advocacy programmes that would ensure that the barriers experienced by the visually impaired are addressed.

3.4.2.3 Addressing the exclusion of persons with visual impairment and blindness through advocacy

To address the exclusion of persons with visual impairment and blindness effectively, there is a need for the government to enact a law on disability rights, which recognises the challenges that the visually impaired and other people with disabilities face in their communities. The policy makers should recognise that the proposed bill on disability would not only benefit the visually impaired and disabled persons but their children and other family members. In addition, it will reduce their dependence on family members and the community.

Another way to ensure social inclusion of persons with visual impairment and other disabilities is to support the community-based rehabilitation (CBR) strategy that was initiated about three decades ago. The CBR strategy is a strategy within general community development for the rehabilitation, equalisation of opportunities and social inclusion of people with disabilities. The strategy promotes collaboration among community leaders, people with disabilities, their families and other concerned citizens to provide equal opportunities for people with disabilities in the communities. The major objectives of CBR are to promote the rights and participation

of people with disabilities and to strengthen the role of their organizations in countries around the world (WHO 2004b).

There is a need for advocacy to

a) Empower persons with visual impairment and their families to know their rights, to have opportunities and tools to express their claims and be able to take action against those who violate their rights.

b) Ensure that civil society organizations fighting for the rights of persons with visual impairment have financial and managerial capacity to carry out their operations; they must have a clear vision about their role, their objectives and their strategies to achieve these objectives and they must have good communication skills to influence policy makers.

c) Ensure that government officials and eye care professionals understand and accept their responsibilities towards persons with visual impairment.

3.5 CONCLUSION

This chapter outlined the risk factors for visual impairment and blindness as well as the possible levels of interventions to prevent visual impairment and blindness. The concept of health promotion and some of its components, which include health education, advocacy for prevention of blindness, advocacy for the rights of people with visual impairment and blindness, and advocacy to address the exclusion of persons with visual impairment and blindness were also outlined.

CHAPTER 4

RESEARCH METHODS

4.1 INTRODUCTION

The preceding chapter outlined the risk factors for DM. The risk factors for diabetic retinopathy, the natural history of diabetic retinopathy (DR), the risk factors for visual impairment and blindness as well as the possible levels of interventions to prevent visual impairment and blindness were discussed in that chapter. The concept of health promotion and some of its components were also discussed in that chapter. The health promotion components included health education, advocacy for the prevention of blindness, advocacy for the rights of people with visual impairment and blindness, and advocacy to address the exclusion of persons with visual impairment and blindness from full participation in society.

In this chapter, the research setting for the study, the research design and the research methods used in this study are discussed. Under the research methods, the study population, sampling method and procedure, eligibility criteria for participating in the study are presented. In addition, the aspects of data collection, which includes the development and structure of the data collection instruments, the rationale for the selected instruments and the data collection process are presented. The reliability of the instruments as well as the validity of the study, data analysis and ethical considerations are also presented in this chapter.

The aim of this study was to determine the prevalence and causes of visual impairment and blindness among Black South African diabetic adults who are 40 years and older in Mopani District, Limpopo province. The research design and method facilitated the achievement of the research objectives, which were to:

- i. Determine the prevalence of visual impairment or blindness among the Black South Africans with DM who are 40 years and older in Mopani District, Limpopo Province.
- ii. Determine the causes of visual impairment or blindness among the Black South Africans with DM who are 40 years and older in Mopani District, Limpopo Province.
- iii. Describe the risk factors which are associated with visual impairment or blindness among the Black South Africans with DM who are 40 years and older in Mopani District, Limpopo Province.

4.2 RESEARCH SETTING

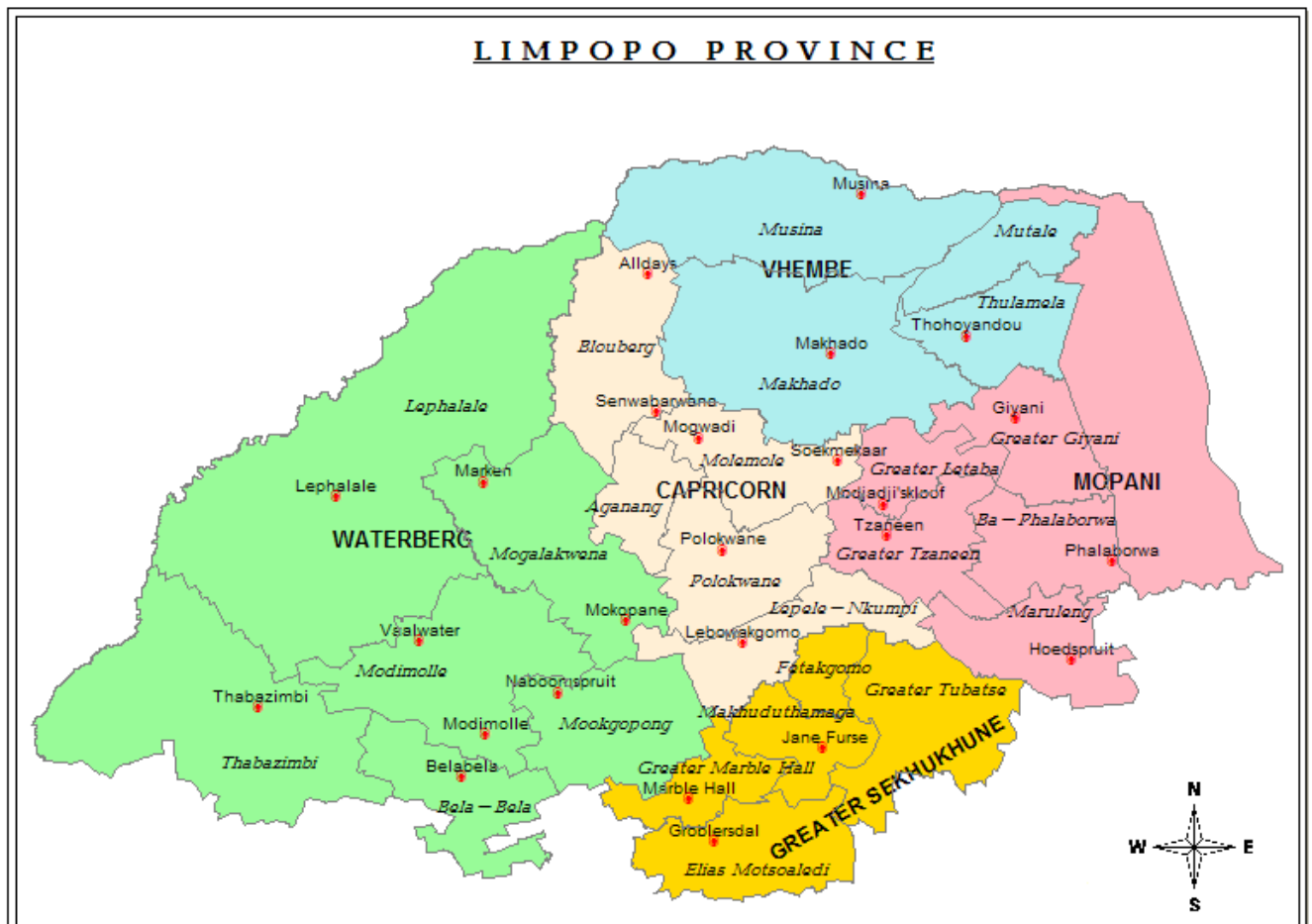
A research setting is defined as a location for conducting a research (Burns and Grove 2003:497). This definition agrees with that by Polit and Beck (2004:28), which states that a research setting is a place that is used for data collection.

This study was conducted in seven sites, which include two hospitals, four clinics and one Health centre in Mopani District in the Limpopo Province. This province was selected because it is one of the poorest in South Africa, with the majority of the population living in the rural areas. It was there expected that the prevalence of visual impairment and blindness among the persons with diabetes will be high due to chronic lack of eye care services. Limpopo Province is home to approximately 5.2 million people. This is 10.6% of the national population (Limpopo DHSD 2011). The province shares borders with the Republics of Mozambique in the east, Zimbabwe in the north and Botswana in the west. The Province also shares borders with the Provinces of Gauteng, Mpumalanga and the North West. It is considered a poor Province with 80% of its people living in rural areas. Limpopo Province has five health districts, which are

Capricorn, Mopani, Sekhukhune, Vhembe, and Waterberg. Mopani district has a population of approximately 1 million. The district has seven district hospitals and 85 fixed clinics (Limpopo DHSD 2011).

For convenience, Mopani Health District was selected for this study. The seven Public Health Facilities for this study were selected from two local municipalities, namely Greater Tzaneen and Greater Letaba Local Municipalities. The three clinics (Dan, Carlota and Tzaneen), Nkowankowa health Centre and Letaba hospital are located in the Greater Tzaneen Local Municipality. This municipality is situated in the eastern quadrant of the Limpopo Province and shares borders with Polokwane to the west, Greater Letaba to the north, Ba-Phalaborwa and Maruleng to the east, and Lepelle-Nkumpi to the south, border the Greater Tzaneen Municipality and Giyani border. This Municipality comprises a land area of approximately 3240 km², and extends from Haenertsburg in the west, to Rubbervale in the east (85km), and just south of Modjadjiskloof in the north, to Trichardtsdal in the south (47km). The Greater Tzaneen Municipality area encompasses the proclaimed towns of Tzaneen, Nkowankowa, Lenyenye, Letsitele and Haenertsburg. Almost 80% of households in this Municipality reside in rural villages (Mopani District Municipality 2009).

Ga-Kgapane clinic and Ga-Kgapane Hospital are located in the Greater Letaba Local Municipality. This is the smallest local municipality in the district in terms of land area and is situated in the west of the Mopani District. The Municipality incorporates the proclaimed towns of Modjadjiskloof, Ga-Kgapane and Senwamokgope, which are situated in the South. Resources are relatively scarce throughout the municipality. The municipality is, however, situated in close proximity of other natural resources at its border with Greater Tzaneen. The Tzaneen and Heanertsburg areas attract tourists due to their natural beauty, dams, waterfalls and nature reserves (Mopani District Municipality 2009).



(<http://www.limpopo-dlgh.gov.za/maps.php>)

Figure 4.1: A map of Limpopo Province showing Mopani district with the other four districts.

4.3 RESEARCH DESIGN

Kumar (2005:84) defines a research design as “a procedural plan that is adopted by the researcher to answer research questions validly, objectively and economically”. Mouton (2001:55) refers to a research design as a plan or a blueprint of how the researcher intends to conduct the research. The focus of a research design is on the final product; it gives an idea of the kind of study that is planned, the kind of results that is to be achieved, and the kind of evidence that is required to answer the questions adequately (Mouton

2001: 55). The above authors agree that a research design is a plan that is needed by researchers to conduct a study that at the end will give answers to research questions.

Cresswell (2009:6) states that the selection of a research design is often based on the researcher's paradigmatic standpoint. In other words, the types of beliefs that the researcher holds often lead them to select a particular research design. The paradigmatic standpoint is usually shaped by the discipline area of the researcher as well as their past research experiences. If the researcher is a student, the beliefs of the advisers also have an influence on the selection of the research design (Creswell 2009:6). Both the discipline area and the researcher's previous research experience influenced the selection of the research design adopted in this study.

4.3.1 Research paradigm

The positivist approach was followed in this study. According to Creswell (2009:7), positivists believe that all events are determined by previously existing causes (deterministic philosophy) and that ideas for instance, can be reduced into small, discrete set of ideas, such as hypothesis and research questions (reductionistic philosophy). Positivists also believe that human behavioural research should be limited to what the researcher can observe and measure objectively, that is, the research must be free of interests, feelings, values, and opinions of the researcher. In other words, positivists believe that reality is fixed and knowledge can be produced objectively through rigorous methodologies. Research carried out by positivists is referred to as quantitative research (Welman 2005:6).

4.3.1.1 Quantitative research design

The researcher used a quantitative research design in this study. Quantitative design is generally used in studies that seek to answer questions about relationships among measured variables with the purpose of explaining, predicting, and controlling phenomenon. Quantitative researchers usually begin with research questions and/or specific hypothesis to be tested. They identify variables they need to study and then use standardised methods to collect some form of numerical data, and use statistical procedures to analyse and draw conclusions from the data (Leedy & Ormrod 2005:94). Bowling (2002:258) adds the fact that a quantitative study is characterised by relatively larger sample, statistical analysis as well as highly structured measuring instruments, which enable the researcher to collect unambiguous and easy to count responses.

In view of the above description of quantitative research design, the researcher felt that quantitative design was most appropriate for this study. The researcher chose a quantitative design because this study requires a relatively larger sample and statistical analysis to answer the research questions properly. In addition, the fact that the method of data collection is relatively cheaper made it an approach of choice. In spite of the above advantages, the quantitative design has some disadvantages. According to Leedy & Ormrod (2005:97) the weakness of a quantitative approach is that it is not conducted in the natural setting, with the result that the findings obtained may not be generalised to a setting that is more naturalistic.

The researcher used technical instruments, including the visual acuity chart, auto refractor, pinhole, and an ophthalmoscope on each participant to determine the presence or absence of visual impairment. A tape measure and a weight scale were used to take anthropometric measurements. In addition, the researcher used structured interviews wherein the participants were asked the same

questions with predetermined responses. The interviewer put a cross on the number corresponding to the participant's response in the record form (Kumar 2005:126).

4.3.1.2 *The study design*

According to Kumar (2005:93), study designs may be classified based on three different perspectives:

- i. The reference period of the study
- ii. The nature of the investigation
- iii. The number of contact with the study population

The reference period of the study refers to a period in which a phenomenon or a problem is explored. Based on the reference period, study designs can be classified into retrospective, prospective and retrospective-prospective. Based on the nature of investigation, study designs can be classified as experimental, non-experimental and semi-experimental. Based on the number of contacts with the study population, study designs can be classified into cross-sectional, before-and-after studies and longitudinal studies

This was a descriptive, non-experimental and a cross-sectional study in which Black South Africans with DM who are 40 years and older in Mopani district were examined for visual impairment and blindness.

The purpose of descriptive studies is to observe, describe, and document aspects of the situation as it naturally occurs and sometimes to serve as a starting point for hypothesis generation and theory development (Polit & Beck 2004:192).

This study was non-experimental since the researcher used unaided and unaided visual acuity of the participants to determine the presence or absence of visual impairment and blindness. In addition, the researcher did auto-refraction and ophthalmoscope examination to establish the probable cause of visual impairment or blindness. The researcher did not manipulate any of the study variables during the entire study. In non-experimental studies, the researcher observes a phenomenon or the outcome and then tries to establish the cause of the change in the dependent variable (kumar 2005:100).

This was a cross-sectional study as the researcher met the participants only once for the purpose of the study. Cross-sectional studies fall under the classification based on the number of contacts with the study population. They help to obtain an overall picture of the phenomenon as it stands at the time of study. Cross-sectional studies are relatively easy and cheap to carry out as they involve only one contact with the study population. The main disadvantage is that these studies cannot measure change, unless if at least two cross-sectional studies are done on the same study population at two points in time (Kumar 2005: 93-94).

Cherry (2012) adds that cross-sectional studies utilise different groups of people who differ in certain variables, but share other characteristics such as socioeconomic status, educational background, and ethnicity. These studies are observational and descriptive in nature and are often used to look at the prevalence of a condition in a given population. The researcher records the information that is present in a population, but does not manipulate variables.

4.4 RESEARCH METHOD

Research method refers to practices and techniques used to collect, analyse and process data (Bowling 2002:143). Burns & Grove

(2001:223) describe the research method as the entire plan of the study, which includes all the steps of the research process from problem identification to the actual data collection.

4.4.1 Study population

The study population in this study consisted of Black South African diabetic adults of both sexes, who were 40 years and older in Mopani District of the Limpopo Province. Burns & Grove (2003:233) define a study population or target population as the total collection of all units of analysis that met the sampling criteria. Concurring with this, Polit & Beck (2004:289) define a study population as the entire aggregation of cases in which the researcher is interested.

4.4.1.1 Accessible population

The accessible population for this study consisted of Black South African adults of both sexes, who were 40 years and older and who received DM services (blood glucose test and diabetes treatment) in the Public Health Facilities in Mopani District of the Limpopo Province. An accessible population is defined as the portion of the target population to which the researcher has reasonable access (Burns & Grove 2003:234).

4.4.1.2 Participants

The participants for this study were 225 Black South African diabetic adults who satisfied the selection criteria; who received DM services from the following health facilities: Letaba hospital, Ga-Kgapane hospital, Ga-Kgapane clinic, Carlota clinic, Tzaneen clinic and Dan clinic, as well as from Nkowankowa Health centre.

4.4.2 Sample, sample size, sampling process and sample selection process

4.4.2.1 Sample and sample size

A sample consists of a selected group or subset of the population or elements or units of analysis from the defined population (Polit & Beck 2004:731).

Sample size for this study was 225 participants. This included all patients who were willing to participate in the study and who met the inclusion criteria. Between 2009 and 2010, there were about 49000 people with diabetes in the Mopani District (Limpopo Department of Health 2011). The prevalence of visual impairment and blindness among the people with DM aged 40 years and older in Mopani District was estimated at 15%. The calculated sample size was 195.

$$N = \frac{z^2 * [P(1-P)]}{D^2}$$

N= Sample size required

Z*Z= 95% Confidence level = 1.96 (two tail)

P=prevalence of VI and blindness=0.15

D² = Acceptable error= 0.0025

The calculated sample size requirement=195

The actual prevalence of VI and blindness is likely to be very different from the 15%. In order to ensure a sufficient sample size, 225 participants were included in this study. In addition, the sample size seemed appropriate because, according to University of South Africa (2012:82), in order to discuss the findings in terms of percentages a minimum of one hundred participants is recommended though not essential.

4.4.2.2 Sampling process

Sampling is a process of drawing a portion of the population to represent the total population and the findings from the sample represent the rest of the population. Sampling has advantages and disadvantages. The advantages are that it saves time as well as financial and human resources. However, the main disadvantage is that the findings from the sample only give the population estimates. (Kumar 2005:164).

There are two main types of sampling, namely probability and non-probability sampling. Probability sampling is the process whereby each participant in the population has an equal chance of being selected. Participants selected in this manner are more likely to be representative of the population than those selected using non-probability sampling (Welman *et al* 2005:56). However, non-probability sampling is the process whereby respondents are selected based on availability and ease of access (Welman *et al* 2005:56).

a) Convenience sampling

Convenience sampling is one method of non-probability sampling, which involves using the most conveniently available people as study participants. The advantages of this method are “ease of recruitment, easier monitoring and follow-up, generally good response rates and retention of sample members” (Bowling 2002:238). Other advantages of this method include the fact that it is inexpensive, accessible and usually less time-consuming than other types of sampling methods. This method provides a means to conduct studies on topics that cannot be done using probability sampling (Burns & Grove 2003:248).

Burns & Grove (2003:248), however, consider convenience sampling a poor approach because it provides little opportunity to control for biases; subjects are included in the study merely because they happen to be in the right place at the right time. Notwithstanding the limitations cited above, the researcher felt that the advantages of this approach far much outweigh its disadvantages. Therefore, the researcher considered convenience sampling the most appropriate approach for this study.

4.4.2.3 Sampling selection process

The researcher obtained permissions from the health-facility managers to conduct the study on the diabetic patients. The sister-in-charge in each clinic assisted the researcher by informing the diabetic patients of the researcher's intentions and the purpose of the study. The researcher explained the purpose of the study and the contents of consent form in the language that the patients understood best. The researcher used convenience sampling to select participants from seven public health facilities. All the patients aged 40 years and older who were booked for diabetes check-up in the selected health facilities were requested to participate in the study. Participants who agreed to participate and satisfied the inclusion criteria were asked to sign a consent form and were then included in the study. The plan was to have an equal number of participants from each health facility, but that did not happen despite several visits to the facilities. This was due to a variety of reasons such as patients preferring to use some facilities to other. However, all the participants who were requested to participate in each facility consented to participate in the study. The number of participants per health facility is shown in brackets: Letaba Hospital(65), Ga-Kgapane Clinic (56), Tzaneen Clinic(32), Carlota Clinic (28), Dan Clinic (16), Nkowankowa health Centre (15) and Ga-Kgapane Hospital (13).

4.4.2.4 Eligibility (inclusion) criteria

Inclusion criteria are a set of characteristics that the participants must possess to be allowed to participate in the study (Polit & Beck 2004:290). All the participants included in this study satisfied the following inclusion criteria: they were Black diabetic adults (of both sexes), 40 years and older, mentally sound, willing to participate and have signed the consent form.

4.4.2.5 Exclusion criteria

Exclusion criteria are set of characteristics that participants lack in order to be allowed to participate in a research study (Polit & Beck 2004:290). Those excluded from this study included diabetic adults who were not Black, those who were 39 years and younger and those who were not willing to sign the consent form.

4.5 DATA COLLECTION

Data collection is “the precise, systematic gathering of information relevant to the research purpose or the specific objectives, research questions, or hypotheses of a study” (Burns & Grove 2003:45). This definition agrees with that by Polit & Beck (2004:716), which defines data collection as the method that is used to collect information needed to conduct a research study.

4.5.1 Data collection approach and method

In addition to vision examination and anthropometric measurements (outlined below), structured data collection approach was used in this study. This approach involves the presentation of fixed questions, batteries of questions, tests, and/or scales to the participants in the same way, with no variation in the wording of the questions. The participants had to choose the correct answer from

pre-coded choices. This method was chosen because of its advantages which are: the collection of unambiguous and easy to count answers, use of statistics to analyse the data, suitability for use in studies requiring larger samples and the fact that it is a relatively cheaper way of data collection (Bowling 2002:258).

4.5.2 Development and structure of the data collection instruments

The research problem, aim and objectives of the study guided the researcher in the development of the instruments. Some of the questions used in the interview schedule were adapted from questionnaires used in a survey by the Central America Diabetes Initiative (2007).

The researcher used three forms of data collection instruments in this study. The first form of the data collection instruments included standard optometric instruments used for vision examination and eye examination to determine the presence or absence of visual impairment. The instruments included the logMAR visual acuity chart (Landolt "C"), Auto-refractor, pinhole and a direct ophthalmoscope.

The second form of data collection instruments included a bathroom scale and a tape measure, which were used to measure body mass, height and waist circumference.

The third form of the instruments was structured interviews wherein participants were asked questions on their socio-demographic characteristics, clinical characteristics of DM, knowledge of DM and its ocular complications, family history, hypertension, smoking habits as well as accessibility to health facilities.

The three sections of data collection in this study are described below

SECTION A: Vision assessment

In the first part of section A, participants responded to a question on whether they are wearing optical correction or not (A1), visual acuity (VA) measurement of those wearing optical correction (A2) and those without (A3). Visual acuity to be measured with auto-refraction results (A4). The researcher had to tick the cause of visual impairment from a list of alternative causes (A5) (See Annexure A).

SECTION B: Anthropometric measurements

The height of the participants was measured using a tape measure and the weight was measured using a bathroom weight scale. The height and weight of the participants were used to determine the Body Mass Index (BMI) (B1). The waist circumference was also measured using a tape measure (B2) (See Annexure A).

SECTION C: Interview schedule

This section consisted of closed questions (Q1 to Q37) (See Annexure A) Firstly, participants responded to questions on their socio-demographic characteristics such as age, ethnic group, educational qualification, monthly income, source of income, and residence type (Q1 to Q6). Secondly, participants responded to questions related to DM, which included duration, knowledge of DM types, treatment, compliance to treatment, place where they check their sugar level, last check-up, knowledge of the complications of DM, eye examination history, family history of DM and visual impairment (Q7 to Q24). Thirdly, participants responded to questions related to hypertension, which included the last time they had their BP checked, whether they have been diagnosed of hypertension or not, treatment used, and compliance to treatment (Q25 to Q32). Fourthly, participants responded to questions on smoking, which

included whether they ever smoked or not, and when they started smoking, how often they smoked currently, when they stopped smoking if they were no longer smoking (Q33 to Q36). The last question was on accessibility to health services; how far they lived from the health facilities (Q37).

4.5.3 Rationale for the selection of the instruments used in the study

4.5.3.1 Optometric instruments

The tests and procedures conducted on each participant included visual acuities, Auto-refraction, pinhole test, and direct ophthalmoscope examination.

a) LogMAR visual acuity chart (Landolt “C”)

Distance visual acuity was measured using the logMAR visual acuity chart (Landolt “C”) (Bailey & Lovie 1976)(See Annexure B) at a distance of 4 metres. The chart was chosen because it is currently recognised as a gold standard for VA measurement in clinical research. The chart has five letters in each row, which ensures that the task is the same for each row. The letter spacing on each row is equal to one letter width and the row spacing is equal to the height of the letters below. In addition, the letter size follows a logarithmic progression, increasing in 0.1 logMAR steps.

b) Auto-refractor

Auto-refractor (CRK7000) (See Annexure C) was used to determine the optical correction on all participants who could not see the 6/9.5 line with either eye on the VA chart. Auto refraction was chosen for this study because of its advantages, which include the reduction of the testing time, an increase in the objectivity of the screening, and the enhancement of the testability of patients who may be poorly

cooperative with traditional screening tests (Chou, Dana & Bougatsos 2011).

c) Pinhole

A pinhole disc was used to check if the reduced visual acuity was due to refractive error or not. This test was chosen because it is one of the quickest ways to determine if the reduced visual acuity of a person is due to refractive error or not.

d) Direct ophthalmoscope

This instrument was used to examine the external and internal structures of the eye to determine the cause of visual impairment or blindness. This instrument was chosen because it is readily available, portable and could be easily used on non-dilated pupils. It is a common and standard equipment for internal and external eye examination. The researcher considered dilating the participants for better view of the fundus, but decided against it because of the unavailability of equipment and expertise to estimate the anterior chamber angle. Therefore, there was a concern that the mydriatic drops might cause angle closure to those with narrow angles.

4.5.3.2 Interview schedule

An interview is any person-to-person interaction between two or more individuals with a specific purpose in mind (Kumar 2005:123). Quantitative researchers sometimes use an interview schedule (a formal written instrument consisting of a set of questions or items) to collect data for a study. The interviewer asks the questions orally in either face-to-face or telephone interviews, and records the participant's replies on the interview schedule (Polit & Beck 2004:349).

The interview method was chosen for this study because it was applicable to most people including the elderly, children, illiterate, and the visually impaired. The response rate is usually higher than in questionnaires, as participants are reluctant to refuse to talk to the interviewer; it is unlikely for the participant to misunderstand questions as the interviewer can either repeat the question or put it in a form that is better understood by the participant (Polit & Beck 2004:351). Structured interviews and closed-ended questions were used in this study as shown in Annexure A.

Structured interviews

Structured interviewing method was chosen because it provides uniform information, which assures comparability of data. In addition, this method requires fewer interviewing skills when compared with unstructured interviewing method (Kumar 2005:126). In a structured interview, each participant is asked a predetermined set of questions, using the same wording and order as specified in the interview schedule. The participant is also asked to respond to the same questions in the same order and with the same set of response options. When developing a structured interview schedule, much effort must be devoted to the content, form, and wording of the questions (Kumar 2005: 126, Polit & Beck 2004:349).

i. Closed-ended questions

Closed-ended questions were also chosen because they are easier to administer and to analyse when compared with open-ended questions. Additionally, administering closed-ended questions is less time-consuming than administering open-ended questions. This is because participants can complete more closed-ended than open-ended questions at a given amount of time. Furthermore, closed-

ended questions are more preferred with persons who are unable to express themselves verbally (Polit & Beck 2004:349).

In closed-ended questions, alternative answers are set out in the interview schedule and the interviewer ticks the category that best describes the participant's answer. The alternative answers may range from a simple "yes" or "no" variety to complex expressions of opinion or behaviour (Polit & Beck 2004:349). Kumar (2005:132) adds that it is usually advisable to provide a category "other/please explain" to accommodate any response not listed.

The major disadvantage of closed-ended questions is the greater possibility of researcher bias, as the researchers are likely to list only the responses that they are interested in while they overlook or neglect other potential responses (Polit & Beck 2004:350). The was reviewed a few times to minimise bias

4.5.4 Research assistants training

The research assistants consisted of an optometrist and three other assistants. The researcher (who is an optometrist) was responsible for visual acuity measurements and ophthalmoscope examination and the other optometrist was responsible for auto-refraction. The other assistants were responsible for conducting interviews and the anthropometric measurements on each participant. Prior to commencement of data collection process, the research assistants were given an intensive training by the researcher on the following:

- a) Orientation to data collection tools, that is, they were shown what instruments were to be used and for what purpose.
- b) Methods of data collection, that is, how to measure visual acuities and auto-refraction.
- c) How to conduct interview and to properly complete the record form.

4.5.5 Pilot Study

A pilot study is a process of administering instruments such as tests or questionnaires to a limited number of subjects from the same population as that for which the main study is intended (Welman *et al* 2005:148).

The purpose of a pilot study was to familiarize the research assistants with all aspects of the study and to identify problem areas requiring attention prior to the implementation of the full study (Welman *et al* 2005:148). The pilot study was done on three Black diabetic adults who were 40 years and older, who receive diabetes treatment from public health facilities in the Mopani district. The three participants used in the pilot study were not included in the main study. The three participants were asked the questions from the interview schedule to determine whether they were understandable or not. Any instructions from the interview schedule that were unclear were corrected, some questions that were omitted were included and the order of the questions was also re-arranged with guidance from the supervisor. All these were done before the main study commenced.

4.5.6 Data collection process

The researcher obtained permission from the health-facility managers to conduct the study on the diabetic patients. The sister-in-charge in each health facility informed the diabetic patients of the researcher's intentions and the purpose of the study. The researcher explained the purpose of the study and the contents of the consent form in the language that the each participant understood best. All the patients who came for diabetes check-up and satisfied the inclusion criteria agreed to participate in the study. Each participant signed the consent form.

4.5.6.1 Visual acuity measurement

The procedure was explained properly to the each participant. Visual acuity (VA) measurements were taken with optical correction on, for participants who were wearing optical correction. For those not wearing optical correction, VA measurements were taken without any optical correction. The right eye was tested first and then the left eye, each time occluding the fellow eye. The participant was asked to identify where the gap of the “C” was facing (left, right, up or down), starting from the top line (6/60). In the case where the orientation of at least four of the five “C’s” in the 6/60 line was correctly identified, then the participant was requested to identify the orientation of the letters in the lower lines of the charts. A participant who could not identify the position of the gap of any of the “C’s” in the 6/60 line was advanced to a 2 metre distance from the chart and VA was taken accordingly. The lowest line read successfully was assigned as the VA of the eye undergoing testing. The best VA line was recorded in logMAR form with a minus or plus signs and numerical value representing the number of letters missed in the best acuity line or read in the next line. For any participant who failed to see the position of the gap of the “C” even at 2 metre distance; the researcher moved his hand and asked the participants to report if they saw the hand movement or not. Visual acuity results for each eye were recorded accordingly in the record form (Annexure A).

For purposes of analysis, each optotype correctly identified by the participant was scored as 0.02 logMAR unit because a change in letter size between one line and the next was 0.1 logMAR, and there five letters in every line (letter scoring method).

4.5.6.2 Auto-refraction

Auto-refraction was done on each participant who could not see the 6/9.5 line with either eye on the VA chart. The participant was

seated comfortably with the chin on the chin rest and the forehead rest of the auto-refractor. The participant was asked to look at the target (image of a parachute) inside the auto-refractor and to report when they were able to see it clearly and the examiner took refractive error measurements according to the instruction manual of the auto-refractor. Findings were recorded appropriately on the record form.

4.5.6.3 Pinhole test

This test was performed on all participants with visual acuity of 6/9.5 or worse to determine if the visual impairment was due to refractive error or not. For a participant not wearing optical correction a pinhole disc placed in front of each eye while the other was occluded. The participant was instructed to look at the VA chart through the pinhole of the disc and VA measurements were taken as usual. The same procedure was done on those wearing optical correction.

Refractive error was recorded as the cause of visual impairment where VA improved to 6/9.5 or better with pinhole. However, where there was no VA improvement with pinhole, the researcher used an ophthalmoscope to establish the cause of visual impairment (Dandona, Dandona, Srinivas, Sahare, Narsaiah, Muñoz, Phokarel, Ellwein 2002:616). Amblyopia was reported to exist when VA was worse than 6/9.5, even with corrective lenses (from auto refraction) and a pinhole. Also, amblyopia was recorded as the cause of vision loss for subjects with no apparent organic lesion and satisfying one or more of the following criteria: 1) esotropia, exotropia, or vertical tropia (strabismic amblyopia) at 2 meters fixation. 2) Anisometropia of $\geq 2.00D$, bilateral ametropia of $\geq +6.00D$, or uncorrected astigmatism of $\geq 3.00D$ in both eyes (refractive amblyopia).

Cataract was assigned as the cause when the fundus was partially or completely obscured by the lens opacity. Glaucoma was assigned

as a cause when the participant reported taking glaucoma medication and/or when glaucomatous disc changes were observed during ophthalmoscopic examination. Corneal opacity was assigned as a cause when the fundus was partially or completely obscured by the opacity. Diabetic retinopathy was assigned as a cause when the following were seen: NVD and NVE, dot/blot haemorrhages, hard exudates, and more than five cotton wool spots in the macula area.

The cause of visual impairment was recorded accordingly on the record form. Only the primary cause of visual impairment was recorded. Where there were two or more primary disorders equally contributing to the visual loss, then the primary cause was assigned to one that is easiest to treat to restore vision (Wei, Chen, Fan & Pathai 2010: 84). On rare cases where the researcher had doubts in determining the cause of visual impairment; the participants were referred to the hospital ophthalmologist for second opinions. All participants with treatable eye condition were referred to the ophthalmic nurses for treatment and/or for referral.

Definition of visual impairment in this study

In this study, the definition of visual impairment and blindness was adapted from the revised categories of visual impairment (VI) by the World health organization (WHO 2011) (see Table 1.1). Participants with visual acuity (VA) of equal to or better than 6/9.5 were categorised as having no VI. Those with VA of worse than 6/9.5, but equal to or better than 6/18 were categorised as having mild VI. Those with VA of worse than 6/18 but equal to or better than 6/60 as having moderate VI; those with VA of worse than 6/60 but equal to or better than 3/60 as having severe VI; and those with VA of worse than 3/60 to no light perception as blind (See Table 4.1).

Table 4.1: Shows the categories of visual impairment and blindness classification

Distance visual acuity		
Category	Worse than:	Equal to or better than:
No VI		6/9.5
Mild VI	6/9.5	6/18
Moderate VI	6/18	6/60
Severe VI	6/60	3/60
Blindness	3/60 to No Light Perception	

4.5.6.4 Anthropometric measurements

The weight and height of each participant were measured to determine the Body Mass Index (BMI). The BMI (kg/m^2) was calculated as weight (kg) divided by height in square metres (m^2) WHO (2004c). They were classified as normal BMI (<25); overweight

($25 \leq 30$); obese (≥ 30) according to WHO (2004c) classification (See Table 4.2).

Table 4.2: The International Classification of adult underweight, overweight and obesity according to BMI

Classification	BMI(kg/m ²)	
	Principal cut-off points	Additional cut-off points
Underweight	<18.50	<18.50
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	18.50 - 24.99	18.50 - 22.99
		23.00 - 24.99
Overweight	≥ 25.00	≥ 25.00
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	≥ 30.00	≥ 30.00
Obese class I	30.00 - 34.99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥ 40.00	≥ 40.00

Source: WHO (2004).

a) Weight and height

The participant was asked to stand on the scale barefooted and try to remain as still as possible to help the scale calculate their weight. The research assistant waited until the dial had stopped before recording the reading. Three readings were taken and the average was recorded in the record form.

The height was also measured with a tape measure with the participant barefooted. Three readings were taken and the average recorded on the record form.

b) Waist circumference

Waist Circumference was determined by locating the upper hip bone of the participant and placing a measuring tape around the abdomen, ensuring that the tape is snug, but does not compress your skin, and is parallel to the floor. The participant is asked to relax and exhale, and then the measurement is taken (Eustice 2012). Three readings were taken and the average recorded in the record form. The waist circumference of each participant was measured, and the findings were recorded appropriately in the record form. Waist circumference of higher than 94cm for males or higher than 80cm for females is associated with an increased risk of diseases of lifestyles. Waist circumference of >102cm for males or >88cm for females is associated with a substantially increased risk of diseases of lifestyles (WHO 2004c) .

4.5.6.5 Interviews

After undergoing the above tests, each participant was directed to where the interviewer was, either in another room (where available) or in the same room, but not too close to the where the other tests were being done. This was done to ensure some privacy and confidentiality during the interview. The interviews were administered as per the interview schedule (Annexure A) and when necessary, the interviewer repeated some questions or put them in a way that was better understood by the participants.

4.6 RELIABILITY AND VALIDITY

4.6.1 Reliability of the data collection instruments

Reliability is the reproducibility and consistency of the data collection instrument (Bowling 2002:147). The instrument should be able to produce the same results every time it is used in the same situation or by different investigators. Before an instrument can be judged as reliable, parameters that need to be assessed include the

following: test-retest reliability, inter-rater reliability and internal consistency (Bowling 2002:147).

All instruments including optometric instruments, anthropometric and the interview schedule were assessed for reliability.

The Auto-refractor was calibrated to give an average of five readings per eye; and “#” sign next to the reading indicated that it was unreliable. In case where there were unreliable readings, the researcher repeated the test until all five readings were shown to be reliable. To ensure reliability of the anthropometric instruments, three readings were taken on each participants and the average was recorded. The interview schedule was pre-tested in a pilot study on three diabetic patients with the same attributes as the study population. This was done to check whether the participants understood the tests and questions the same way or not. Any instructions from the interview schedule that were unclear were corrected, some questions that were omitted were included and the order of the questions was also re-arranged.

4.6.2 Validity

Validity of the research design refers to the “accuracy, meaningfulness and credibility of the research project as a whole” (Leedy & Ormrod 2005:97). These authors reckon that the research effort would be worthwhile if meaningful and defensible conclusions could be drawn from the study. Validity is concerned with the soundness of the study’s evidence, whether the findings are cogent, convincing, and well grounded (Polit & Beck 2004:36). In the case of research methods the validity question focuses on whether there is evidence to support the assertion that the research methods are really measuring what they purport to measure or not (Polit & Beck 2004:36). External and statistical validity are outlined hereunder.

4.6.2.1 External validity

External validity is the extent to which the study findings can be generalised beyond the study sample (Burns & Grove 2003:200, Bowling 2002:150). The sampling method used in this study limits the generalisation of the research findings to the entire population of interest. However, the fact that the pathogenesis of DM and diabetic retinopathy is similar in all people with DM regardless of where they live makes it possible for the findings to be generalised to all people with diabetes using public health facilities in the Limpopo Province. In addition, the fact that all the participants who came for diabetes check-up participated in the study implies that the sample may be representative of all the people with DM using public health facilities in the Limpopo Province.

4.6.2.2 Statistical conclusion validity

Statistical conclusion validity is the extent to which the conclusions drawn from statistical analyses about relationships or differences between variables or groups are the true reflection of reality or not. Type 1 error occurs when the researcher concludes that relationships or differences exist between variables or groups when in reality they do not. Type 2 error occurs when the researcher concludes that there are no significant relationships between variables or groups when in reality there are (Burns & Grove 2003:199). In cases where statistical analysis revealed no significant relationships between variables in this study, power analysis was performed to ensure that no type 2 error occurred.

4.6.3 Biases and errors

Burns & Grove (2003:197) refer to a bias as a deviation from the true, or expected. Bias in a study tends to distort the findings from what they should be without the bias. Research designs are

therefore developed to minimise the possibility and effects of bias. Concurring with the above, Polit & Beck (2004:36) refer to a bias as an influence that produces a distortion in the study results. Biases and errors in conceptualisation of the research idea, the research design, and the sampling process in a study threaten the validity and reliability of the investigation (Bowling 2002:153).

The sampling procedure in this study did not allow all members of the population of interest to have equal chance to be included in a study sample, which led to a sampling bias (Bowling 2002:156). As indicated above that the pathogenesis of DM and diabetic retinopathy is similar in all people with DM regardless of where they live. This suggests that sampling bias will not have a major impact on the findings of the study.

4.7 DATA ANALYSIS

Data were analyzed using the Statistical Analysis System (SAS) version 9.2 software package. This software package was selected due to its availability and ease of access. Categorical data analysis procedure was used where one-way (one variable) and two-way (two variable) cross-tabulation tables, frequency tables and graphs were constructed. The chi-square tests of associations between pairs of variables as well as logistic regression were performed and odds ratios were calculated and interpreted.

The distribution of visual impairment or blindness in each eye was tabulated as a function of the various risk factors. Logistic regression was used to estimate the strength of association between visual impairment or blindness and the various risk factors.

The Chi-square tests of association showed that there was no association between visual impairment and blindness and the socio-demographic and clinical risk factors for DM at the 0.05 level of significance. However, there was an association between these

variables at the 0.1 level of significance. Consequently, the 0.1 level of significance was used in this study.

4.8 ETHICAL CONSIDERATIONS

An important ethical aspect of a research study is having the research project approved and permission to conduct the study granted by relevant authorities. Approval to conduct this study was obtained from the relevant authorities. Annexure D shows the letter requesting approval from the Department of Health Studies, University of South Africa (UNISA) to conduct the study and Annexure E shows the approval by the Research and Ethics Committee of the Department of Health Studies in UNISA. Annexure F is a letter requesting permission to conduct the study from the Limpopo Provincial Department of Health and Annexure G is a letter of permission to conduct the study granted by Department of Health in Limpopo Province. Annexure H shows the letter requesting permission from Dr CN Phathudi Hospital to conduct the study within the hospital and in the clinics under its jurisdiction; and Annexure I contains the approval by the hospital CEO. Annexure J shows a letter requesting permission from the Letaba hospital to conduct study within the hospital and in the clinics under its jurisdiction; and Annexure K shows permission to conduct the study granted by the hospital CEO. (The annexure D-K are at the end of this chapter).

According to Leedy & Ormrod (2005:101) most ethical issues fall into the following four categories: Protection from harm, informed consent, right to privacy, and honesty with professional colleagues.

4.8.1 Protection from harm

“The right to protection from discomfort and harm from a study is based on the ethical principle of beneficence, which states that one should do good and, above all, do no harm” (Burns & Grove 2003:175). The researcher in this study is an optometrist and all

tests performed in this study were within the scope of optometric practice in South Africa. All tests were non-invasive and did not present any harm or discomfort to the participants. None of the various aspects of the interviews could pose psychological discomfort to the participants.

4.8.2 Informed consent

Informed consent requires the researcher to disclose specific information to all prospective subjects and that participants voluntarily agree to participate in the study. The researcher ensured that each participant had the competence to give consent, understood what the study was all about, and were voluntarily willing to participate in the study. The researcher explained the purpose of the study and the details regarding the tests to the participants. They were also informed that participation in the study was voluntary and that they could withdraw at any time should they so desire without any penalty (See Annexure L).

An informed consent form (Annexure M) was given to the eligible participant to sign. Participants were encouraged to ask questions for clarification on any matter before they signed the form. Leedy & Ormrod (2005:101) cautioned that participants should be given just enough information about the study to enable them to decide whether they want to participate or not. These authors warn that giving more information may lead the participants to respond in a way as to please the researcher. Only participants with signed forms were included in the study. The results of the vision examination were made available to the participants confidentially.

4.8.3 Right to privacy

Based on the right to privacy, participants in a research study have the right to anonymity and confidentiality therefore; the participants in this study were promised confidentiality, anonymity and privacy.

The researcher ensured that the participant's name or identity could not be linked in any way with their responses. This was done by allocating participant numbers so that no participant's names could be found in the research reports. Burns & Grove (2003:171) define privacy as the freedom that an individual has to decide on the time, extent and circumstances under which their private information would be shared or withheld from others. During and after the study, all data sheets were kept in a secured locker and electronic versions protected by passwords. The hard copies will be destroyed by shredding and electronic versions deleted at appropriate time after the study completion.

4.9 CONCLUSION

In this chapter, the research setting for this study was discussed. The research design and the research methods that were used in this study were also discussed. Under the research methods, the study population, sampling method and procedure, eligibility criteria were presented. In addition, the method of data collection, which includes the development and structure of the data collection instruments, the rationale for the selected instruments and the data collection process were presented. The reliability of the instruments as well as the validity of the study, data analysis and ethical considerations was also presented in this chapter.

CHAPTER 5

RESULTS

5.1 INTRODUCTION

The research setting for this study was discussed in chapter 4. The research design and the research methods that were used in this study were also discussed in that chapter. Under the research methods, the study population, sampling method and procedure, eligibility criteria were presented. In addition, the method of data collection, which includes the development and structure of the data collection instruments, the rationale for the selected instruments and the data collection process were presented. The reliability of the instruments as well as the validity of the study, data analysis and ethical considerations was also presented in that chapter.

In this chapter, the results obtained from the vision examination, anthropometric measurements and interviews conducted on the participants is presented. In addition to the narrative presentation of results, Tables and Figures are presented. This chapter is divided into four sections and in the first section, the following were presented: Distribution of the participants per public health facility; Socio-demographic characteristics of the participants (age, gender, marital status, occupation, ethnic groups, educational qualifications, monthly income, source of household income and places of residence) as well as the anthropometric measurements (body mass index and waist circumference).

In the second section, the prevalence and distribution of visual impairment and blindness (based on presenting visual acuity) as well as their relationship to the various socio-demographic and anthropometric characteristics are presented. In addition, the prevalence and distribution of visual impairment and blindness (after

optical correction) as well as their relationship to the various socio-demographic and anthropometric characteristics are presented.

In the third section, the causes of visual impairment and blindness before and after optical correction among the participants are presented. The fourth section consists of the results of the clinical risk factors for visual impairment and blindness. These factors include duration of DM, knowledge of DM types, types of DM, types of diabetes treatment, and knowledge of DM and its complications, history eye examination, family history of DM, hypertension and its treatment types, smoking status and accessibility to health facilities.

5.2 THE NUMBER OF PARTICIPANTS PER PUBLIC HEALTH FACILITY

The number of participants selected from each public health facility for this study ranged from 13 to 65. Table 5.1 shows the number and percentages of participants from each public health facility. About a third of the participants (28.9%) were from Letaba hospital and a few (5.8%) were from Ga-Kgapane hospital.

Table 5.1: Shows the number and percentages of the participants from each of the seven public health facility. The percentages varies from 5.8 at Ga-kgapane hospital to 28.9 at Letaba hospital

Health facility	Number (N) of participants	Percentages (%)
Carlota clinic	28	12.4
Dan clinic	16	7.1
Ga-kgapane clinic	56	24.9
Ga-Kgapane hospital	13	5.8
Letaba hospital	65	28.9
Nkowankowa health centre	15	6.7
Tzaneen clinic	32	14.2
Total	225	100

5.3 SOCIO-DEMOGRAPHY OF THE PARTICIPANTS

The participants included in this study were 225 Black South African diabetic adults 40 years and older in the Mopani District, Limpopo Province. Their ages ranged from 40 to 90 years with a mean of 61.5 ± 10.49 [Standard deviation (SD)] years (Table 5.20). There were more females 161 (71.5%) than males 64 (28.4%) in this study (Figure 5.1). A larger percentage of the participants in this study were married and a few were divorced or separated (Table 5.3). Many of the participants were pensioners (Figure 5.2) and they belonged to the Sotho ethnic group (Figure 5.3). There were few participants with tertiary educational qualification in this study, and over 40% had primary educational qualification (Figure 5.4). The source of income of many of the participants was old-age pension, hence over half of them received a monthly income of between R1001 and R2000 (Figures 5.5 and 5.6). Many of the participants lived in the rural areas

5.3.1 Age distributions of the participants

Over half (54.7%) of the participants were 60 years and older, while a few (5.3%) were in the 45-49 years age range. Four percent (4%) of the participants did not know their ages (See Table 5.2).

Table 5.2: The distribution (number and percentages) of the participants by age ranges. Many were 60 years and older.

Age (years)	Number (N)	Percentages (%)
40-44	13	5.8
45-49	12	5.3
50-54	36	16
55-59	32	14.2
60 and older	123	54.7
unknown	9	4
Total	225	100

5.3.2 Distribution of the participants by gender and ages

The numbers of both females (81) and males (42) respectively were higher in the 60 years and older age range. The number of females was lower ($N = 25$) between the ages of 40 and 49 years and there were no males in this age range (See Figure 5.1).

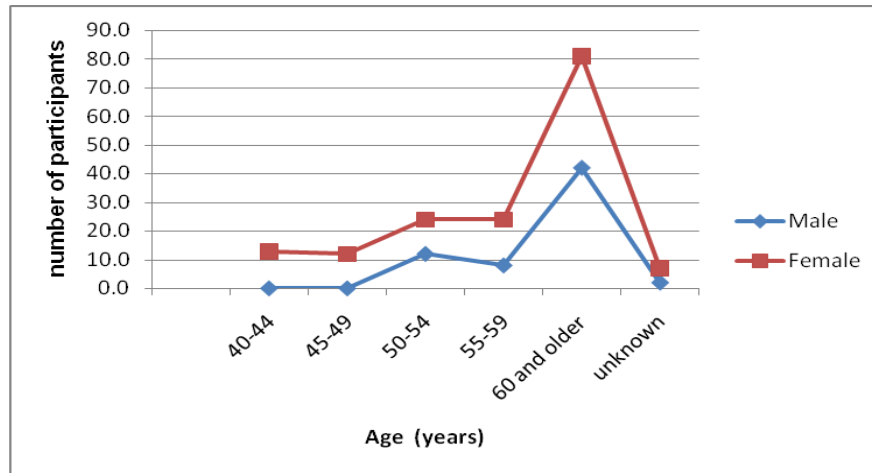


Figure 5.1 Distribution of the participants according to gender and age.

5.3.3 The distribution of the participants by marital status

Over half (55.1%) of the 225 participants were married, while a few (9.3%) were either divorced or separated. See Table 5.3 for the number and percentages of these and other marital status.

Table 5.3: Shows the number and percentages of the participants according to the marital status.

Marital status	Number (<i>N</i>)	Percentages (%)
Single	31	13.8
Married	124	55.1
Divorced/separated	21	9.3
Widowed	49	21.8
Total	225	100

5.3.4 The distribution of the participants according to occupations

Many (60.4%) of the participants were pensioners. A few were self employed (3.1%). The percentages of these and other occupational categories are shown in Figure 5.2.

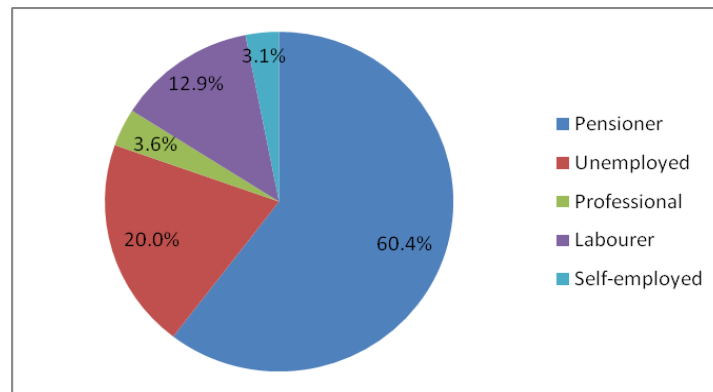


Figure 5.2: The distribution of the participants according to occupations

5.3.5 The distribution of the participants according to ethnic groups

The participants were mostly Sotho-speaking (53.8%) or Shangaan (43.6%) as shown in Figure 5.3.

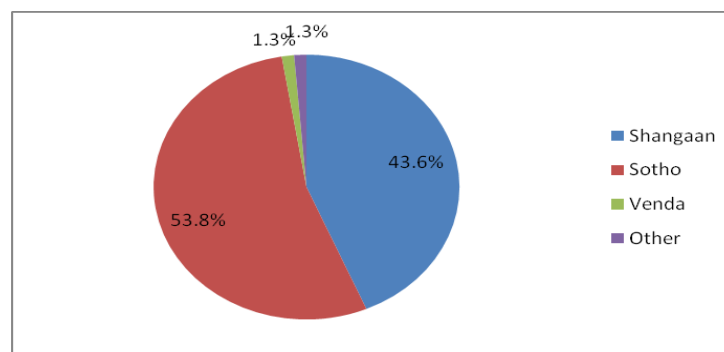


Figure 5.3: The distribution of the participants according to ethnic groups. Other in the figure refers to Zulu, Xhosa etc.

5.3.6 The distribution of the participants according to educational qualifications

Just over forty percent (41.3%) of the participants had primary school education and only a few (6.7%) had tertiary educational qualification. Other educational categories are shown in Figure 5.4.

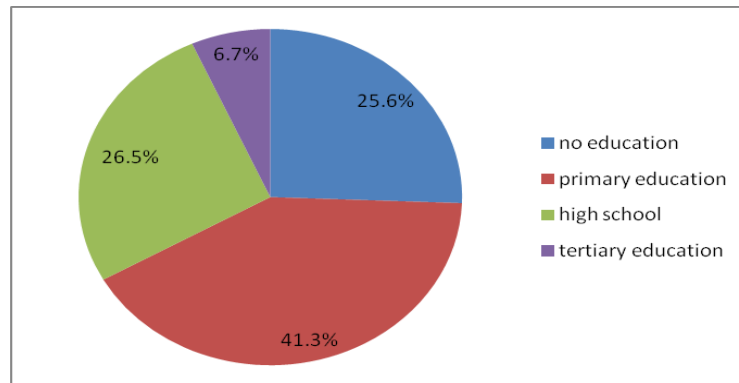


Figure 5.4: The distribution of the participants according to educational qualifications

5.3.7 The distribution of the participants according to monthly income

The monthly income of the participants is shown in Figure 5.5. Over half of the participants (55.6%) earn R1001-R2000 and approximately 15% did not receive any income. Other income categories are shown in Figure 5.5.

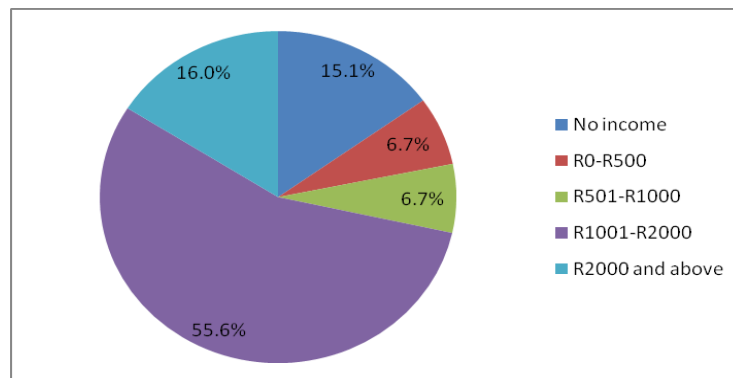


Figure 5.5: The distribution of the participants according to monthly income.

5.3.8 The distribution of the participants according to source of household income

The source of household income for many (61.3%) of the participants was old-age pension. Only 8.3% received income from formal employment. Approximately 10% of the participants did not have any source of income (See Figure 5.6).

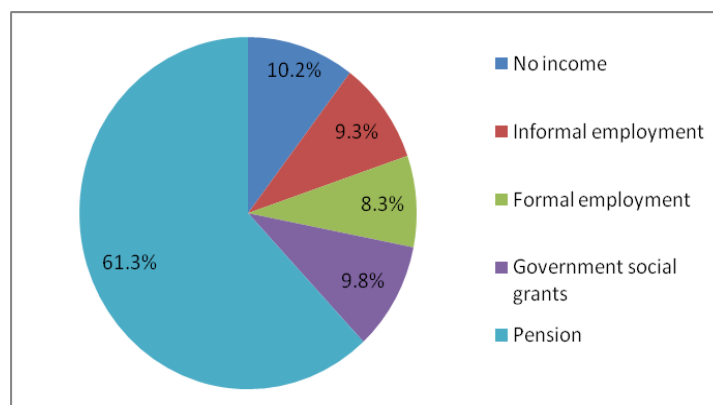


Figure 5.6: The distribution of the participants according to source of household income.

5.3.9 The distribution of the participants according to place of residence

Many (68.9%) of the participants were residing rural areas. The other places of residence are illustrated in Figure 5.7.

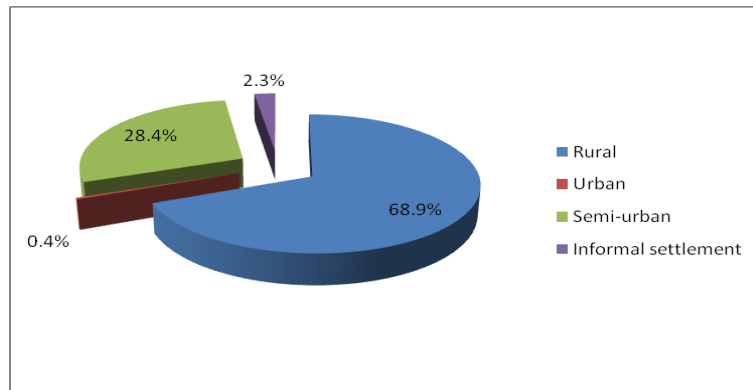


Figure 5.7: The distribution of the participants according to the place of residence.

5.3.10 The distribution of Body Mass Index and waist circumference of the participants

For various reasons such as participants leaving early for doctor's appointment, to go and fetch children from preschool, etc, the researcher could not take Body Mass Index (BMI) measurements on all the participants, hence BMI were taken for only 200 participants ($N=60$) (30%) males and ($N=140$) (70%) females. For these participants, the BMI ranged from 10 to 43.9 kg/m^2 with a mean of 29.7 ± 5.31 (SD). Thirty-nine percent (39%) of the participants were overweight ($25\text{--}29.99\text{kg/m}^2$) and 42% were obese ($\geq 30\text{kg/m}^2$). The percentages of those who were underweight ($<18.5\text{ kg/m}^2$) and normal weight ($18.5\text{--}24.99\text{kg/m}^2$) were 1% and 18%, respectively.

The BMI values for the male participants ranged from 18 to 41.3 kg/m^2 with a mean of 27.9 ± 4.9 (SD) and for the females, they ranged from 10 to 43.9 kg/m^2 with a mean of 30.47 ± 5.31 (SD).

Over a third (36.7%) of the male participants were overweight (25-29.99kg/m²) while nearly half of the female participants (48.6%) were obese (≥ 30 kg/m²) (See Figure 5.8).

Waist circumference (WC) was measured for 211 participants ($N=61$) (28.9%) males and ($N=150$) (71.1%) females. The WC ranged from 72 to 203cm with a mean of 106.96 (SD \pm 14.99). For the male participants, it ranged from 72 to 203 cm with a mean of 106.01 \pm 19.46 (SD) and from 84 to 188 with a mean of 107.32 \pm 12.79 (SD) for the female participants.

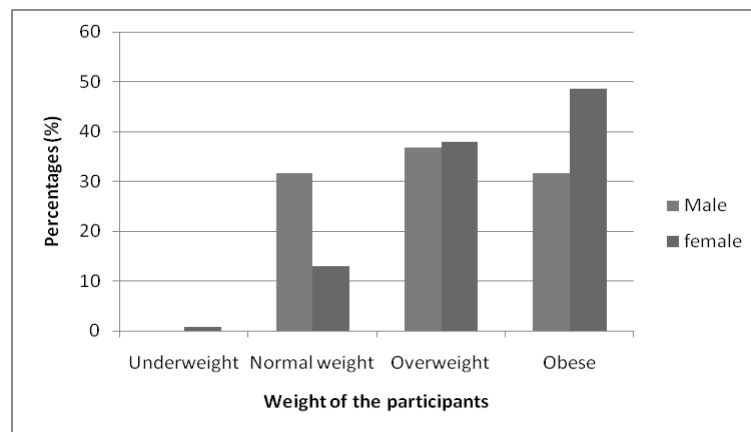


Figure 5.8: Classification of adult underweight, normal weight, overweight and obesity among the participants according to Body Mass Index by gender

5.4 THE PREVALENCE OF VISUAL IMPAIRMENT AND BLINDNESS AMONG THE PARTICIPANTS, BASED ON PRESENTING VISUAL ACUITY

The prevalence of visual impairment and blindness were firstly presented based on the presenting visual acuity (PVA). Most of the visual acuities (VA's) were taken without optical correction worn, because about 88% of the participants were not wearing any optical correction. As indicated in the methodology, visual impairment and blindness were categorised as follows: "Mild"= PVA of worse than 6/9.5, but better and equal to 6/18 ($PVA < 6/9.5$ to $6/18$);

“Moderate”= PVA of worse than 6/18, but better and equal to 6/60 (PVA < 6/18 to \geq 6/60); “severe”= PVA of worse than 6/60, but better and equal to 3/60 (PVA<6/60 to \geq 3/60); “Blind”= PVA of worse than 3/60 (PVA <3/60). Based on the above classification, the following results were obtained.

Among the total participants ($N=225$) who took part in this study, 74.2% of the right eyes had visual impairment and blindness, while 25.8% had normal vision. Of the 74.2% who had visual impairment and blindness in the right eye, 70.7% had visual impairment (PVA<6/9.5 to \geq 3/60) and 3.6% had blindness (PVA<3/60). A large proportion (56%) of the right eyes had moderate visual impairment and a few (3.6%) had blindness. The categories of visual impairment in the right eyes are shown in Table 5.4.

Table 5.4: The category of uncorrected visual impairment, number (N) of eyes and prevalence of visual impairment in the right eyes of the participants.

Category	number (N)	Prevalence (%)
Mild VI	23	10.2
Moderate VI	126	56.0
Severe VI	10	4.4
Blindness	8	3.6
Total	167	74.2

Among the 225 participants who participated in this study, 75.1% of the left eyes had visual impairment and blindness, while 24.8% had normal vision. Of the 75.1% who had visual impairment and blindness in the left eye, 72% had visual impairment (PVA<6/9.5 to \geq 3/60) and 3.1% had blindness (PVA<3/60). A large proportion (57.8 %) of the left eyes had moderate visual impairment and a few (3.1%) had blindness. The categories of visual impairment in the left eyes are shown in Table 5.5.

Table 5.5: The category of uncorrected visual impairment, number (*N*) of eyes and prevalence of visual impairment in the left eyes of the participants.

Category	Number (<i>N</i>)	Prevalence (%)
Mild VI	23	10.2
Moderate VI	130	57.8
Severe VI	9	4
Blindness	7	3.1
Total	169	75.1

In both eyes, there was a significant difference in percentages in the categories of visual impairment (For the right eyes, chi-square=132 with 3 degrees of freedom and p -value<0.0001; for the left eyes, chi-square=145 with 3 degrees of freedom and p <0.0001). The percentage of the visually impaired people with DM (>74%) was significantly higher than that of people with DM without visual impairment (<26%) (Chi-square test of equality of percentages; p < 0.0001).

5.4.1 Socio-demographic risk factors for visual impairment and blindness

Chi-square tests of association of visual impairment and blindness with various factors were performed. The conclusions from these tests are valid only if all the cell counts are at least five for each variable. Thus in situations where cell counts were less than 5; adjacent categories/levels of ordinal variables/factors were combined in order to make the cell counts at least 5 (Gavin, Wamboldt, Sorokin, Levy & Wamboldt 1999). The categories “severe visual impairment” and “blindness” were combined because the cell counts of each of them were less than five.

Table 5.6: Shows the risk factors, results of chi-square tests of association (visually impaired), number of participants (N) and percentages. Columns 2, 3 and 4: degrees of freedom, value chi-square (χ^2) test statistic, p-value of the test.

Risk factors	Visually impaired/blind			N (%)
	df	χ^2	p-value	
Gender	1	0.7	0.385	224(99.6)
Age	4	5.7	0.222	225(100)
Marital status	3	2.1	0.554	225(100)
Ethnic group	1	1.5	0.219	219(97.3)
Educational qualification	3	9.7	0.021	223(99.1)
Monthly income	4	10.1	0.039	225 (100)
Residence	1	0.8	0.369	219(97.3)
Body mass index	2	0.0	0.994	200(88.9)
Waist circumference	5	0.6	0.990	224(99.6)

5.4.1.1 The prevalence of visual impairment and blindness according to ages of the participants

The prevalence of visual impairment and blindness (PVA<6/9.5 to <3/60) in the right eyes of the participants was high (58.1%) among those who were 60 years and older, and low (3.6%) among those in the 40 to 44 years age range (See Figure 5.9). Similarly, the prevalence in the left eyes of the participants was high (59.2%) among those who were 60 years and older and low among those between the age of 40 and 49 years (4.7%) (See Figure 5.10). There was no significant association between visual impairment and blindness and age ($df=4$, $\chi^2 =5.7$, $p\text{-value}=0.222$).

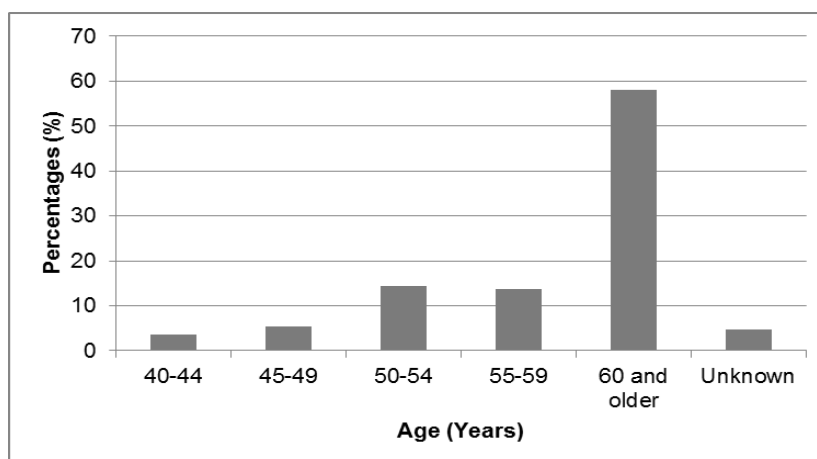


Figure 5.9: The prevalence of uncorrected visual impairment and blindness by age of the participants (Right eyes). The prevalence was higher among those who were 60 years and older.

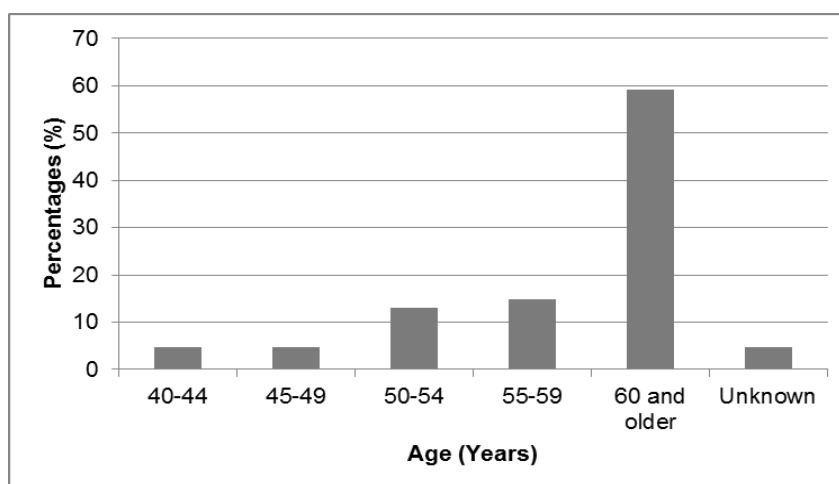


Figure 5.10: The prevalence of uncorrected visual impairment and blindness by age of the participants (Left eyes). The prevalence was higher among those who were 60 years and older.

5.4.1.2 The prevalence of visual impairment and blindness by gender

The prevalence of visual impairment and blindness was higher among the male than among the female participants. Among the males, the prevalence was 78.1% and 82.8%, in the right and left eyes respectively. Among the females, it was 72.5% in both the right and the left eyes. The association between gender and visual impairment and blindness was statistically insignificant ($df=1$, $\chi^2 = 0.7$, $p=0.385$).

5.4.1.3 The prevalence of visual impairment and blindness by educational qualification (Right eyes)

A two-sided paired t-test was used to compare the means of the visual acuities (VA's) of the right and left eyes. The results (t -value=0.47 with $df=224$, $p=0.638$) at the 0.1 level of significance showed that there was no significant difference between the means of the VA's of the two eyes. It was therefore decided that where applicable data from the right eye was used (details in Chapter 6).

The prevalence of visual impairment and blindness was high (32.7%) among participants with primary education and low (3.6%) among those with tertiary education. Among the 57 participants with no education, 82.5 % (47/57) were visually impaired, and 17.5% (10/57) had normal vision (see Table 5.7). The association between education qualification and visual impairment and blindness was statistically significant ($df =3$, $\chi^2=9.7$, $p=0.021$) at the 0.1 level of significance.

Table 5.7: The prevalence and distribution of visual status by educational qualification (Right eyes)

Educational qualification	Visually impaired/blind N (%)	Not visually impaired N (%)	Total N (%)
No education	47 (21.1)	10 (4.5)	57 (25.6)
Primary school	73 (32.7)	19 (8.5)	92 (41.3)
High school	38 (17)	21 (9.4)	59 (26.5)
Tertiary	8 (3.6)	7 (3.1)	15 (6.7)
Total	166(74.4)	57 (25.5)	223 (100)

5.5.1.4 The prevalence of visual impairment and blindness by monthly income (Right eyes)

The prevalence of visual impairment and blindness was higher (52%) among participants earning \leq R2000 than those earning $>$ R2000 (10.2%) (Table 5.8). There was a significant association between visual impairment and blindness and monthly income ($df=2$, $\chi^2=0.928$, $p=0.039$) at the 0.1 level of significance. The probability of those earning between R1001-R2000 being visually impaired is 3.14 times that of those earning R2000 and higher.

Table 5.8: The prevalence and distribution of visual status by monthly income (Right eyes)

Monthly income	Visually impaired/blind N(%)	Not visually impaired N (%)	Total N (%)
No income	27 (12)	7 (3.1)	34 (15.1)
R0-R500	11 (4.9)	4 (1.8)	15 (6.7)
R501-R1000	7 (3.1)	8 (3.6)	15 (6.7)
R1001-R2000	99 (44)	26 (11.6)	125 (55.6)
$>$ R2000	23 (10.2)	13 (5.8)	36 (16.0)
Total	167 (74.2)	58 (25.8)	225 (100)

5.4.1.5 Prevalence of visual impairment and blindness according to marital status

The prevalence of visual impairment and blindness among the widowed, the divorced/separated, the single and the married was 87.8% (43/49), 80.9% (17/21), 74.2% (23/31) and 67.7% (84/124), respectively (See Figure 5.11). There was no significant association between marital status and visual impairment and blindness ($df=3$, $\chi^2=2.1$, $p=0.554$).



Figure 5.11: The prevalence of uncorrected visual impairment and blindness by marital status

5.4.1.6 The prevalence of uncorrected visual impairment and blindness according to place of residence

The prevalence of visual impairment and blindness among those who lived in the rural, informal settlement, semi-urban, urban and other areas was 76.1% (118/155), 50% (2/4), 70.3% (45/64), and 100% (1) for urban and other areas, respectively (See Figure 5.12). There was no association between visual impairment and blindness and place of residence ($df=1$, $\chi^2 = 0.8$, $p=0.369$).

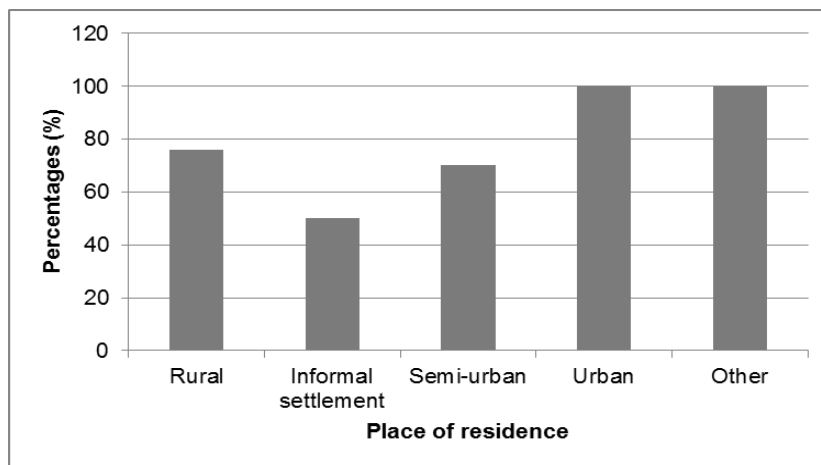


Figure 5.12: The prevalence of uncorrected visual impairment and blindness according to place of residence

5.4.1.7 The prevalence of uncorrected visual impairment and blindness according to ethnic groups

The prevalence of visual impairment and blindness among the Sotho, Shangaan, Venda and Other ethnic group was 77.7% (94/121), 70.4% (69/98), 33.3% (1/3) and 100% (3/3), respectively (See Figure 5.13). There was no significant association between visual impairment and blindness and ethnicity ($df = 1$, $\chi^2 = 1.5$, $p = 0.220$).

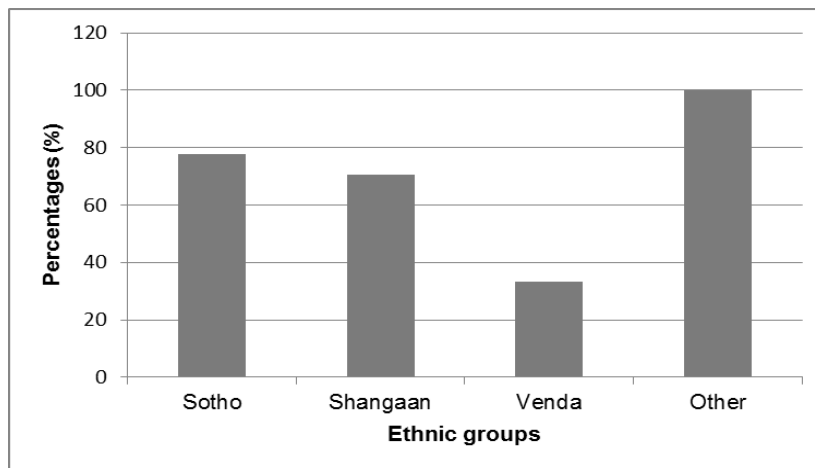


Figure 5.13: The prevalence of uncorrected visual impairment and blindness among different ethnic groups. Other in this figure refers to Xhosa, Zulu, Swazi ethnic groups etc.

5.4.2 Anthropometric risk factors for visual impairment and blindness

5.4.2.1 *The prevalence of visual impairment and blindness by weight categories according to Body Mass Index*

The prevalence of visual impairment and blindness was the highest (42.9%) among participants who were obese and the lowest (0.7%) among those who were underweight (See Figure 5.14). There was no association between visual impairment and blindness and BMI ($df=2$, $\chi^2=0.2$, $p=0.928$)

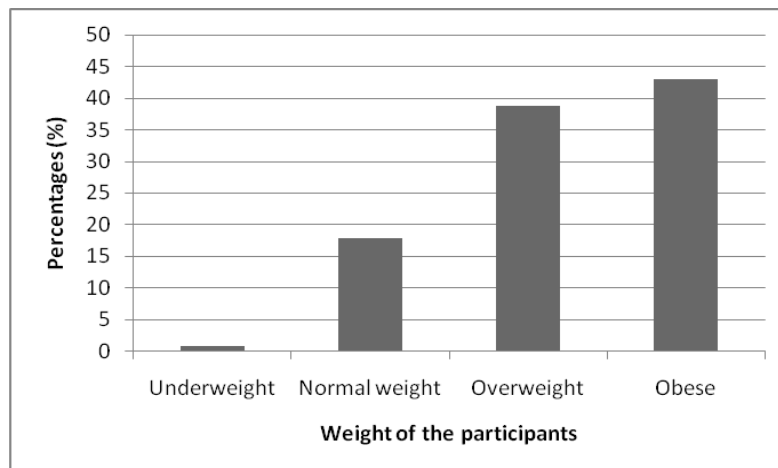


Figure 5.14: The prevalence of uncorrected visual impairment and blindness by weight categories according to Body Mass Index

5.4.2.2 *The prevalence of uncorrected visual impairment and blindness by weight categories according to waist circumference*

The prevalence of visual impairment and blindness was higher among males with >94cm waist circumference (WC) (81.9%) than among those with ≤94cm WC (66.7%). Among the females, the prevalence was 72.7% among those with >80cm, and there were no

females with WC of ≤ 80 cm. There was no association between visual impairment and blindness and WC ($df=5$, $\chi^2=2.8$, $p=0.737$).

5.5 PREVALENCE OF VISUAL IMPAIRMENT AND BLINDNESS AMONG THE PARTICIPANTS AFTER OPTICAL CORRECTION

With optical correction, the prevalence of visual impairment and blindness (AVA $<6.9.5$ to $<3/60$) in the right eyes decreased from 74.2% to 44.9%, and the percentage of right eyes with normal vision increased from 25.8% to 55.1%. Of the 44.9% of the right eyes with visual impairment and blindness, 41.3% had visual impairment and 3.6% had blindness. About a third (31%) of those with visual impairment had moderate visual impairment (AVA $<6/18$ to $\geq 6/60$) (See Table 5.9)

Table 5.9: The categories of corrected visual impairment (VI), number (N) of eyes and prevalence of visual impairment and blindness in the right eyes

Category	Number (N)	Prevalence (%)
Mild VI	15	6.7
Moderate VI	70	31
Severe VI	8	3.6
Blindness	8	3.6
Total	101	44.9

In the left eyes, the prevalence of visual impairment and blindness decreased from 75.1% to 45.3% and the percentage of those with normal vision increased from 24.9% to 54.7%. Of the 45.3% with visual impairment and blindness, 42.2% had visual impairment and 3.1% had blindness (See Table 5.10).

Table 5.10: The categories of corrected visual impairment (VI), number (*N*) of eyes and prevalence of visual impairment in the left eyes

Category	Number (<i>N</i>)	Prevalence (%)
Mild VI	21	9.3
Moderate VI	67	29.8
Severe VI	7	3.1
Blindness	7	3.1
Total	102	45.3

The chi-square test of equality of the percentages of the participants in the categories of visual impairment and blindness in both eyes indicated inequality in both eyes (For the right eyes: chi-square=144, 3 degree of freedom, $p < 0.0001$; for the left eyes: chi-square=135, 3 degree of freedom, $p < 0.0001$).

5.5.1 Socio-demographic risk factors for corrected visual impairment and blindness

The results of the chi-square tests of association between visual impairment and blindness variables and socio-demographic risk factors as well as the anthropometric risk factors are shown in Table 5.11.

Table 5.11: Shows the risk factors, results of chi-square tests of association (visually impaired), number of participants (*N*) and percentages (%). Columns 2, 3 and 4 show degrees of freedom, value chi-square (χ^2) test statistic, *p*-value of the test.

Risk factors	Visually impaired/blind			<i>N</i> (%)
	<i>df</i>	χ^2	<i>p</i> -value	
Gender	1	0.1	0.799	224(99.6)
Age	4	11.2	0.02	225(100)
Marital status	3	3.8	0.285	225(100)
Ethnic group	1	1.0	0.326	219(97.3)
Educational qualification	3	5.2	0.156	223(99.1)
Monthly income	4	14.0	0.007	225 (100)
Residence	1	1.1	0.299	219(97.3)
Body mass index	2	0.0	0.994	200(88.9)
Waist circumference	5	0.6	0.990	224(99.6)

5.5.1.1 The prevalence of corrected visual impairment and blindness according to age of the participants

The prevalence of visual impairment and blindness (AVA<6/9.5 to <3/60) in the right eyes of the participants was 29.3% among those who were 60 years and older, 0.9% among those in the 40 to 44 years age range (See Figure 5.15). The prevalence in the left eyes of the participants was 29.8% among those who were 60 years and older and 0.9% among those between the age of 40 and 44 years (See Figure 5.16). There was a significant association between visual impairment and blindness and age at the 0.1 level of significance ($df=4$, $\chi^2 =11.2$, $p\text{-value}=0.02$).

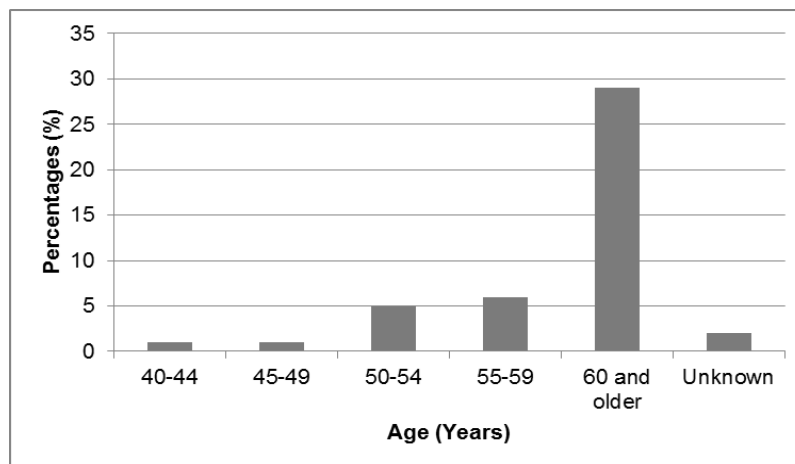


Figure 5.15: The prevalence of corrected visual impairment and blindness by age of the participants (Right eyes)

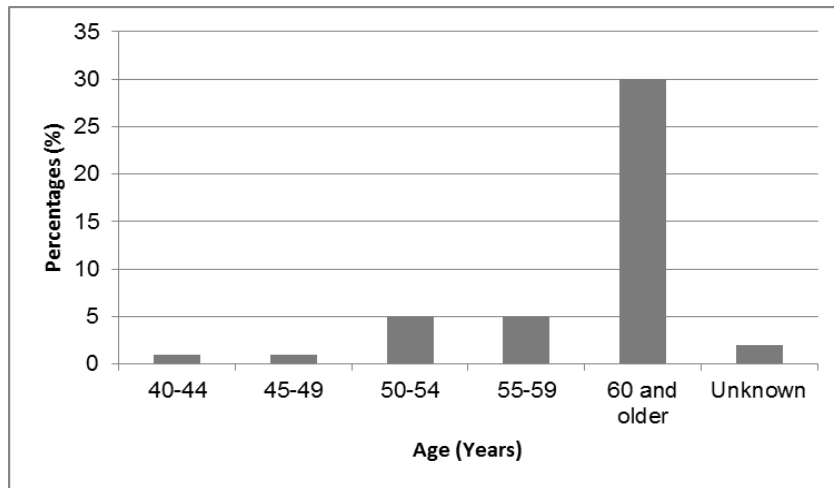


Figure 5.16: The prevalence of corrected visual impairment and blindness by age of the participants (Left eyes)

5.5.1.2 The prevalence of corrected visual impairment and blindness by gender

The prevalence of visual impairment and blindness in the right and left eyes of males was 50% and 43.8%, respectively. Among the females, it was 45.6 % and 43.8% in the right and the left eyes, respectively. The association between visual impairment and blindness and gender was statistically insignificant ($df=1$, $\chi^2 = 0.1$, $p=0.799$).

5.5.1.3 The prevalence of corrected visual impairment and blindness according to educational qualifications (Right eyes)

The prevalence of visual impairment and blindness was 19.3% among participants with primary education and 2.7% among those with tertiary education. Among the 57 participants with no education, 54.4% (31/57) were visually impaired, and 45.6% (26/57) had normal vision (see Table 5.9). The association between education qualification and visual impairment and blindness was not statistically significant ($df=3$, $\chi^2=5.2$, $p=0.156$).

Table 5.12: The prevalence and distribution of visual status by educational qualification (Right eyes)

Educational qualification	Visually impaired/blind N (%)	Not visually impaired N (%)	Total N (%)
No education	31 (13.9)	26 (11.7)	57 (25.6)
Primary school	43 (19.3)	49 (39.8)	92 (41.2)
High school	20 (9)	39 (31.7)	59 (26.5)
Tertiary	6 (2.7)	9 (7.3)	15 (6.7)
Total	100(44.8)	123(55.2)	223 (100)

5.5.1.4 The prevalence of corrected visual impairment and blindness according to monthly income (Right eyes)

The prevalence of visual impairment and blindness was higher (29.8%) among participants with a monthly income of ≤R2000 than among those earning >R2000 (4%) (See Table 5.13). There was a significant association between visual impairment and blindness and monthly income ($df=4$, $\chi^2=14.0$, $p=0.007$).

Table 5.13: The prevalence and distribution of visual status by monthly income (Right eyes)

Monthly income	Visually impaired/blind <i>N</i> (%)	Not visually impaired <i>N</i> (%)	Total <i>N</i> (%)
No income	17 (7.6)	17 (7.6)	34 (15.1)
R0-R500	4 (1.8)	11 (4.9)	15 (6.7)
R501-R1000	4 (1.8)	11 (4.9)	15 (6.7)
R1001-R2000	67 (29.8)	58 (25.8)	125 (55.6)
>R2000	9 (4)	27 (12)	36 (16.0)
Total	101 (44.9)	124 (55.1)	225 (100)

5.5.1.5 Prevalence of corrected visual impairment and blindness according to marital status

The prevalence among the single, married, the divorced/separated, and the widowed was 51.6% (16/31), 41.1% (51/124), 42.9% (9/21) and 61.2% (30/49), respectively (See Figure 5.17). There was no significant association between marital status and visual impairment and blindness ($df=3$, $\chi^2=3.8$, $p=0.285$).

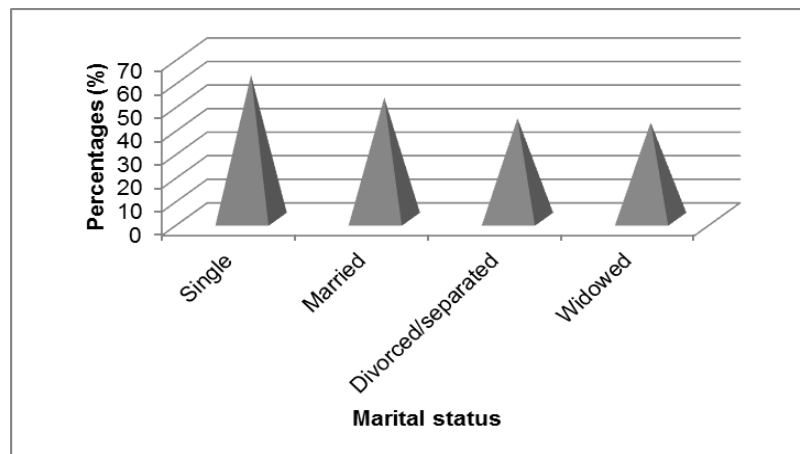


Figure 5.17: The prevalence of visual impairment and blindness by marital status

5.5.1.6 The prevalence of corrected visual impairment and blindness according to place of residence

The prevalence among those living in the rural and semi-urban areas was 43.9% (68/155) and 51.6% (33/64), respectively. There was no visual impairment and blindness among those living in the other places of residence as illustrated in Figure 5.18. There was no significant association between visual impairment and blindness and place of residence ($df=1$, $\chi^2=1.1$, $p=0.299$).

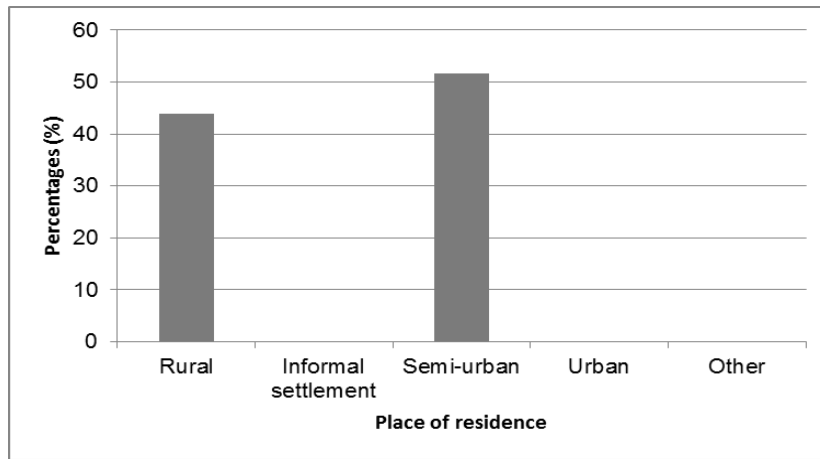


Figure 5.18: The prevalence of visual impairment and blindness according to place of residence

5.5.1.7 The prevalence of corrected visual impairment and blindness according to ethnic groups

The prevalence among the Sotho, Shangaan, Venda and Other ethnic group was 41.3% (50/121), 50% (47/98), 33.3% (1/3) and 100% (3/3), respectively (See Figure 5.19).. There was no significant association between visual impairment and blindness and ethnic groups ($df=1$, $\chi^2 =1$, $p=0.326$).

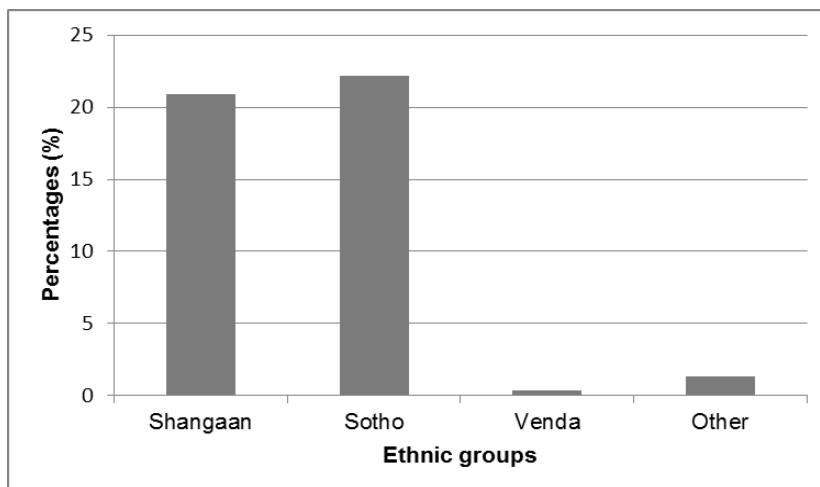


Figure 5.19: The prevalence of visual impairment and blindness according to ethnic groups

5.5.2 Anthropometric risk factors for visual impairment and blindness

5.5.2.1 *The prevalence of corrected visual impairment and blindness by weight categories according to Body Mass Index*

The prevalence of visual impairment and blindness was the highest (18.5%) among participants who were obese and the lowest (1%) among those who were underweight (Figure 5.20). There was no association between visual impairment and blindness and BMI ($df=2$, $\chi^2=0.0$, $p=0.994$).

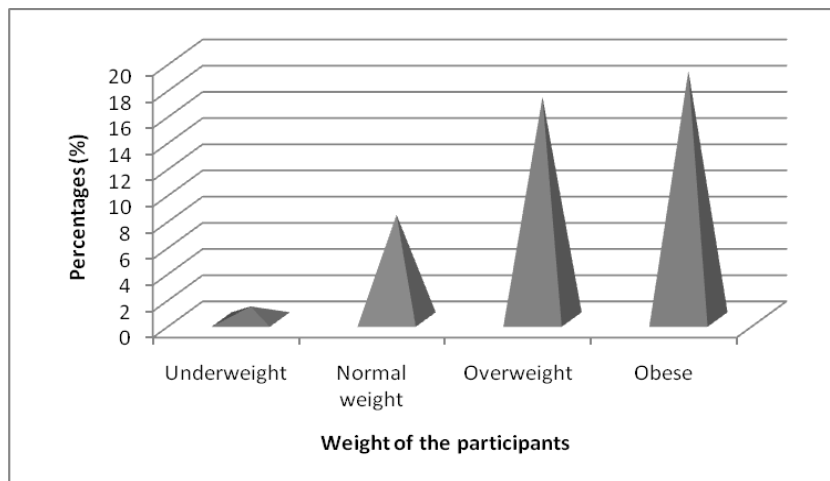


Figure 5.20: The prevalence of visual impairment and blindness by weight categories according to Body Mass Index

5.5.2.2 *The prevalence of visual impairment and blindness by weight categories according to waist circumference*

The prevalence of visual impairment and blindness among the males with waist circumference of $>94\text{cm}$ was 46% and it was 36.4% among those with waist circumference of $\leq 94\text{cm}$. Among the females, the prevalence was 53.9% among those with WC $>80\text{cm}$. There were no females with $\leq 80\text{cm}$ waist circumference. There was no association

between visual impairment and blindness and waist circumference ($df=5$, $\chi^2=0.6$, $p=0.990$)

5.6 THE CAUSES OF VISUAL IMPAIRMENT AND BLINDNESS AMONG THE PARTICIPANTS BEFORE OPTICAL CORRECTION

The main causes of visual impairment and blindness in decreasing order are shown in Table 5.14.

The leading cause of visual impairment and blindness in both eyes of the participants was refractive error (49.5%), followed by cataract (24.7%), diabetic retinopathy (3.8%), and glaucoma (2.2%). In some cases, the cause of visual impairment and blindness in the right eye was different from the cause in the left eye of the participants; therefore, these causes were grouped together as illustrated in Table 5.14. About 5% of visual impairment and blindness was due to other causes such as stroke, strabismus, retinal scars, *etc* (See Table 5.14).

The total number of participants (182) in Table 5.14 is more than the 167 reported previously in Table 5.4. This is because a participant may be visually impaired due to more than one cause. For instance, refractive error may be the cause in one eye and cataract the cause in the other as illustrated in Table 5.14.

Table 5.14: The causes of visual impairment and blindness in eyes, number and percentages of participants

Causes of visual impairment and blindness	Number (<i>N</i>) of participants	Percentages (%)
Refractive error	90	49.5
Cataract	45	24.7
Cataract and refractive error	18	9.9
Other	9	4.9
Diabetic retinopathy	7	3.8
Glaucoma	4	2.2
Diabetic retinopathy and refractive error	2	1.1
Glaucoma and refractive error	2	1.1
Amblyopia and refractive error	2	1.1
Amblyopia	1	0.6
Corneal opacity	1	0.6
Corneal opacity and cataract	1	0.6
Total	182	100

5.6.1 The causes of uncorrected visual impairment and blindness in the right and left eyes of the participants

The leading causes of visual impairment and blindness among the right eyes of the participants was refractive error (50.9%) and cataract (32.3%) (See Figure 5.21). Other causes were responsible for 5.4% of visual impairment and blindness in these eyes. Similarly, in the left eyes, refractive error (52%) was the leading cause of visual impairment and blindness, followed by cataract (31.4%), glaucoma (3.6%) etc. Other causes were responsible for 4.7% of visual impairment and blindness in these eyes (See Figure 5.21).

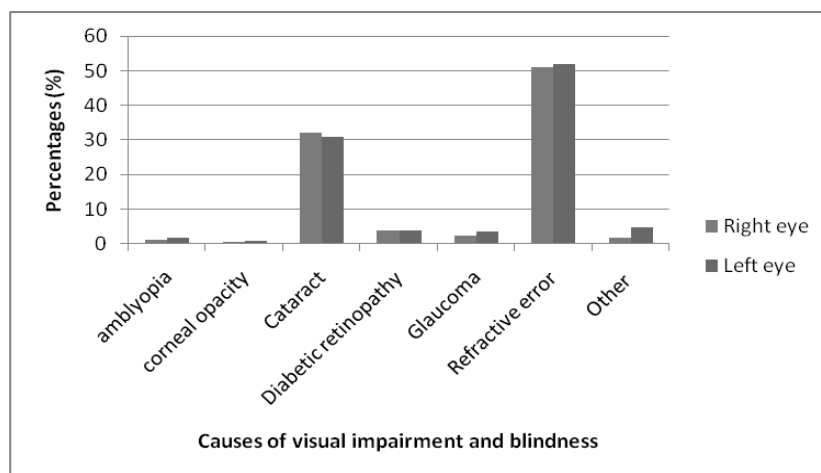


Figure 5.21: The causes of uncorrected visual impairment and blindness in the right and left eyes of the participants

5.6.2 The causes of uncorrected visual impairment and blindness in the right and left eyes of the participants by gender

The prevalence of visual impairment and blindness due to refractive error in the right eyes of males and females was 62% and 44.4% respectively. The prevalence due to cataract in the right eyes of males and females was 22% and 36.7%, respectively (See Figure 5.22).

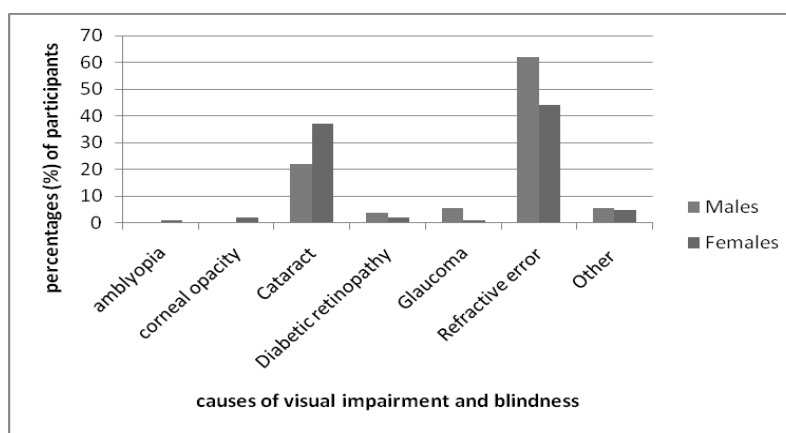


Figure 5.22: The causes of uncorrected visual impairment and blindness in the right eyes of males and females

In the left eyes, the prevalence due to refractive error among the males was 52.8% and among the females was 42.7%). The prevalence due to cataract was 22.6% and 39.3% among the males and females, respectively (See Figure 5.23).

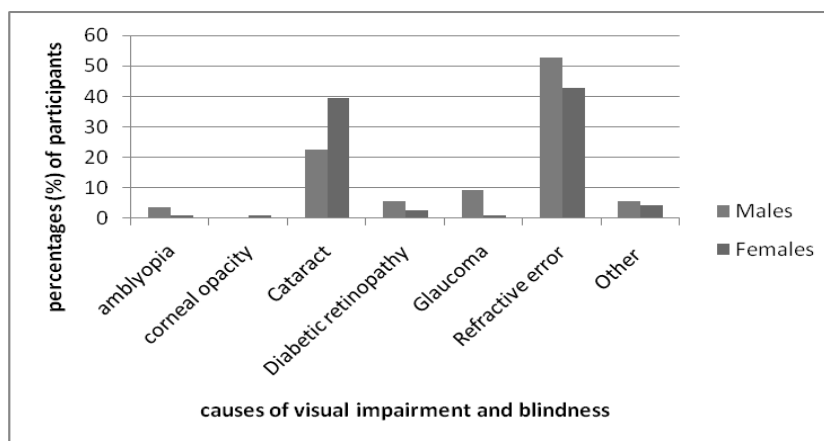


Figure 5.23: The causes of uncorrected visual impairment and blindness in the left eyes of males and females

5.6.3 The causes of uncorrected visual impairment and blindness in the right and left eyes of the participants by age

In both the right and the left eyes of the participants, cataract was the major cause of visual impairment and blindness among those between the ages of 60 years and older. However, below the age of 60 years, refractive error was the major cause (Table 5.15 and 5.16).

Table 5.15: The distribution of the causes of uncorrected visual impairment and blindness in the right eyes of the participants by age

Cause	Age group (Years)			
	40-49 N (%)	50-59 N (%)	≥60 N (%)	Unknown N (%)
Refractive error	8 (61.5)	34 (73.9)	39 (43.8)	4 (57.1)
Cataract	2 (15.4)	5 (10.9)	43 (48.3)	3 (42.9)
Diabetic retinopathy	0	3 (6.5)	4 (4.5)	0
Glaucoma	1 (7.7)	1 (2.2)	2 (2.2)	0
Corneal opacity	1 (7.7)	0	1 (1.1)	0
Amblyopia	1 (7.7)	0	0	0
Other	0	3 (6.5)	0	0

Table 5.16: The causes of uncorrected visual impairment and blindness in the left eyes of the participants by age

Cause	Age group (Years)			
	40-49 N (%)	50-59 N (%)	≥60 N (%)	Unknown N (%)
Refractive error	10 (71.4)	35 (79.6)	40 (39.2)	2 (28.6)
Cataract	1 (7.1)	2 (4.6)	49 (48)	4 (57.1)
Diabetic retinopathy	0	3 (6.8)	3 (2.9)	0
Glaucoma	1 (7.1)	1 (2.2)	2 (2)	1 (14.3)
Corneal opacity	1 (7.1)	0	0	0
Amblyopia	1 (7.1)	0	2 (2)	0
Other	0	3 (6.8)	6 (5.9)	0

5.7 CAUSES OF VISUAL IMPAIRMENT AND BLINDNESS AFTER OPTICAL CORRECTION

The leading cause of visual impairment and blindness in both eyes of the participants after optical correction was cataract (76.8%), followed by diabetic retinopathy (7.1%) and glaucoma (3.6%). About 8% of visual impairment and blindness was due to other causes such as stroke, strabismus, retinal scars, etc (See Table 5.17).

The total number of participants (112) in Table 5.17 below is more than the 101 reported previously in Table 5.8. This is because a participant may be visually impaired due to more than one cause. For instance, cataract may be the cause in one eye and refractive error the cause in the other as illustrated in Table 5.17.

Table 5.17: The causes of corrected visual impairment and blindness in eyes, number (*N*) and percentages of participants

Causes	Number (<i>N</i>)	Percentages (%)
Cataract	86	76.8
Other	9	8
Diabetic retinopathy	8	7.1
Glaucoma	4	3.6
Amblyopia	3	2.7
Corneal opacity	2	1.8
Total	112	100

5.7.1 The causes of corrected visual impairment and blindness in the right and left eyes of the participants

The leading cause of corrected VI and blindness among the right eyes of the participants was cataract (76.5%), followed by DR (6.1%) and glaucoma (4.1%). Other causes were responsible for 9.2% of VI and blindness in these eyes. Similarly, in the left eyes, cataract (75.8%) was the leading cause, followed by DR (7.1%) and glaucoma (4%). Other causes were responsible for 8.1% of visual impairment and blindness in these eyes (See Figure 5.24).

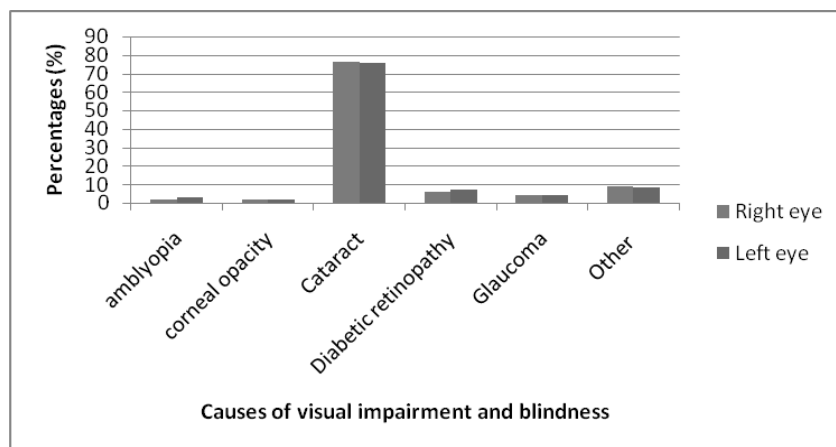


Figure 5.24 The causes of corrected visual impairment and blindness in the right and left eyes of the participants.

5.7.2 The causes of corrected visual impairment and blindness in the right and left eyes of the participants by gender

The prevalence of corrected VI and blindness due to cataract was 78.3% and 70.3% in the right eyes of males and females, respectively. Glaucoma was the cause in 11.1% of the right eyes of males and 1.4% in those of females (See Figure 5.25). Cataract was the major cause in the left eyes of females (82%) than in those of males (59%). However, DR was more prevalent in the left eyes of males (9.4%) than in those of females (4.5%) (See Figure 5.26).

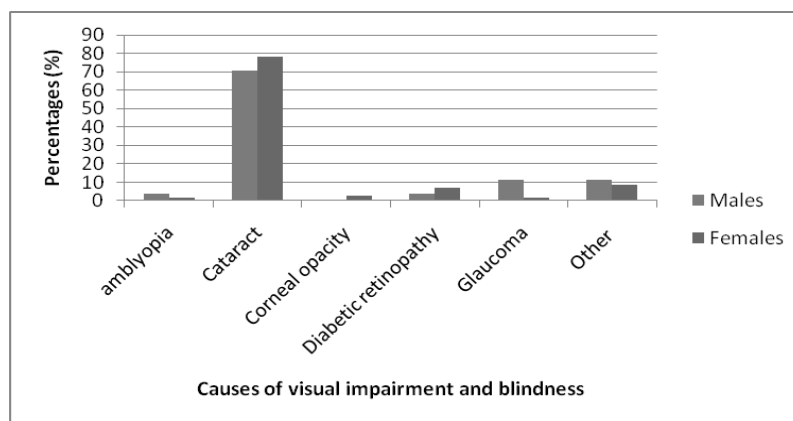


Figure 5.25: The causes of corrected visual impairment and blindness in the right eyes of males and females

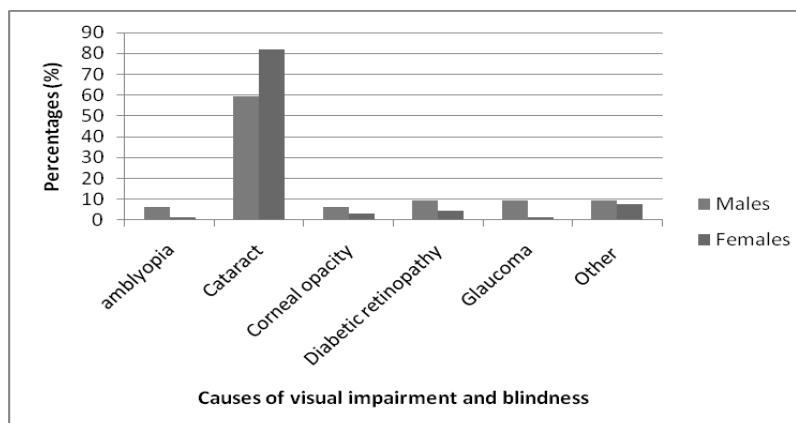


Figure 5.26: The causes of corrected visual impairment and blindness in the left eyes of males and females

5.7.3 The causes of corrected visual impairment and blindness in the right and left eyes of the participants by age

In both the right and left eyes of the participants, cataract was the major cause of visual impairment and blindness among those who were 60 years and older. Diabetic retinopathy was not found in participants below the age of 50 years as shown in Tables 5.18 and 5.19.

Table 5.18: The causes of corrected visual impairment and blindness in the right eyes of the participants by age

Cause	Age group (Years)			
	40-49 <i>N</i> (%)	50-59 <i>N</i> (%)	≥60 <i>N</i> (%)	Unknown <i>N</i> (%)
Cataract	1 (25)	17 (68)	52 (81.3)	5 (100)
Diabetic retinopathy	0	3 (12)	3 (4.7)	0
Glaucoma	1 (25)	1 (4)	2 (3.1)	0
Corneal opacity	1 (25)	1 (4)	0	0
Amblyopia	1 (25)	0	1 (1.6)	0
Other	0	3 (4)	6 (9.4)	0

Table 5.19: The causes of corrected visual impairment and blindness in the left eyes of the participants by age

Cause	Age group (Years)			
	40-49 N (%)	50-59 N (%)	≥60 N (%)	Unknown N (%)
Cataract	1 (25)	14 (66.7)	54 (81.8)	5 (83.3)
Diabetic retinopathy	0	3 (14.3)	3 (4.6)	0
Glaucoma	1 (25)	1 (4.8)	2 (3)	1 (16.7)
Corneal opacity	1 (25)	0	0	0
Amblyopia	1 (25)	0	2 (3)	0
Other	0	3 (14.3)	5 (7.6)	0

5.8 CLINICAL RISK FACTORS FOR VISUAL IMPAIRMENT AND BLINDNESS AMONG THE PARTICIPANTS (UNCORRECTED AND CORRECTED VISION)

A two-sided paired t-test was used to compare the means of the visual acuities (VA's) of the right and left eyes. The results (t -value=0.47 with $df=224$, $p=0.638$) at the 0.1 level of significance showed that there was no significant difference between the means of the VA's of the two eyes. In addition, factors that constitute risk factors for visual impairment and blindness in the right eye will also be a risk factor the left eye. It was therefore decided that the data for the right eyes would be used in the analyses of the risk factors for visual impairment and blindness.

The results of the chi-square(χ^2) tests of association between visual impairment and blindness variables and the diabetes- categories of visual impairment variables being “not visually impaired/blind” and “visually impaired/blind” are shown in Table 5.20a, 5.20b, 5.21a and 5.21b.

Table 5.20a: Shows the results of chi-square tests of association of uncorrected visual impairment and blindness; *N* (%) represent the number and percentages of participants who responded to each question.

Risk factors	Visually impaired/blind			<i>N</i> (%)
	<i>df</i>	χ^2	<i>p</i> -value	
Duration of DM	3	3.6	0.302	225 (100)
Types knowledge	2	6.5	0.038	222 (98.7)
DM type	1	4.3	0.119	222 (98.7)
Insulin	1	0.4	0.553	221 (98.2)
pills	1	4.3	0.038	223 (99.1)
Special diet	1	0.0	0.988	220 (97.8)
Losing weight	1	5.9	0.015	204 (90.7)
Physical activity	1	1.5	0.227	207 (92.0)
Special diet compliance	1	0.9	0.330	213 (94.7)
Weight loss compliance	2	6.5	0.039	117 (52)
Physical activity compliance	2	0.6	0.724	145 (64.4)
Date for last DM check-up	1	0.4	0.549	224 (99.6)
Diabetes family history	2	7.1	0.029	220 (97.8)

Table 5.20b: Shows the results of chi-square tests of association of uncorrected visual impairment and blindness; *N* (%) represent the number and percentages of participants who responded to each question.

Risk factors	Visually impaired/blind			<i>N</i> (%)
	<i>df</i>	χ^2	<i>p</i> -value	
Knowledge that DM can cause VI	1	0.7	0.399	224 (99.6)
Knowledge that DM can cause DR	1	1.8	0.181	223 (99.1)
Knowledge that DM can cause glaucoma	1	0.1	0.804	224 (99.6)
Eye examination history	1	0.0	0.970	217 (96.4)
Last eye examination	4	4.7	0.317	119 (52.9)
Family members with VI	2	0.5	0.792	169 (75.1)
Date for last BP check-up	1	0.5	0.469	225 (100)
Hypertension	1	0.0	0.975	217 (96.4)
hypertension treatment	1	0.2	0.636	177 (78.7)
Smoking status	3	3.9	0.274	213 (94.7)
Age when started smoking	4	2.3	0.559	225 (100)
Accessibility to health services	4	0.6	0.693	219 (97.3)

Table 5.21a: Shows the results of chi-square tests of association of corrected visual impairment and blindness; *N* (%) represent the number and percentages of participants who responded to each question.

Risk factors	Visually impaired/blind			<i>N</i> (%)
	<i>df</i>	χ^2	<i>p</i> -value	
Duration of DM	3	1.8	0.614	225 (100)
Types knowledge	2	0.2	0.920	222 (98.7)
DM type	1	0.1	0.714	222 (98.7)
Insulin	1	0.0	0.931	221 (98.2)
pills	1	1.1	0.306	223 (99.1)
Special diet	1	0.1	0.705	220 (97.8)
Losing weight	1	1.0	0.314	204 (90.7)
Physical activity	1	6.0	0.014	207 (92.0)
Special diet compliance	1	0.5	0.468	213 (94.7)
Weight loss compliance	2	9.4	0.009	117 (52)
Physical activity compliance	2	2.6	0.278	145 (64.4)
Date for last DM check-up	1	1.4	0.238	224 (99.6)
Diabetes family history	2	2.4	0.305	220 (97.8)

Table 5.21b: Shows the results of chi-square tests of association of corrected visual impairment and blindness; *N*(%) represents the number and percentages of participants who responded to each question.

Risk factors	Visually impaired/blind			<i>N</i> (%)
	<i>df</i>	χ^2	<i>p</i> -value	
Knowledge that DM can cause VI	1	0.8	0.359	224 (99.6)
Knowledge that DM can cause DR	1	0.3	0.601	223 (99.1)
Knowledge that DM can cause glaucoma	1	0.0	0.973	224 (99.6)
Eye examination history	1	1.3	0.255	217 (96.4)
Last eye examination	4	9.1	0.059	119 (52.9)
Family members with VI	2	0.3	0.859	169 (75.1)
Date for last BP check-up	1	0.5	0.469	225 (100)
Hypertension	1	0.2	0.652	217 (96.4)
hypertension treatment	1	0.5	0.463	177 (78.7)
Smoking status	3	4.4	0.214	213 (94.7)
Age when started smoking	4	2.4	0.660	225 (100)
Accessibility to health services	4	2.2	0.693	219 (97.3)

5.8.1 Duration of diabetes mellitus

Nearly forty percent (39.6%) of the participants had DM for less than 5 years duration and just below five percent (4.9%) had it for more than 20 years (Table 5.22).

Table 5.22: Shows the duration of diabetes mellitus, number (*N*) of participants and the percentages

Duration (years)	Number (N)	Percentages (%)
< 5	89	39.6
5-10	67	29.8
11-15	38	16.9
16-20	10	4.4
>20	11	4.9
unknown	10	4.4
Total	225	100

5.8.1.1 The prevalence of visual impairment and blindness according to duration of diabetes mellitus

The prevalence of visual impairment and blindness was (16.4%) among those with < 5 years duration of DM, and (2.7%) among those with duration of >20 years (See Figure 5.27). There was no significant association between duration of DM and visual impairment and blindness [degree of freedom (df)=3, chi-square statistic (χ^2)=1.8, p =0.614] .

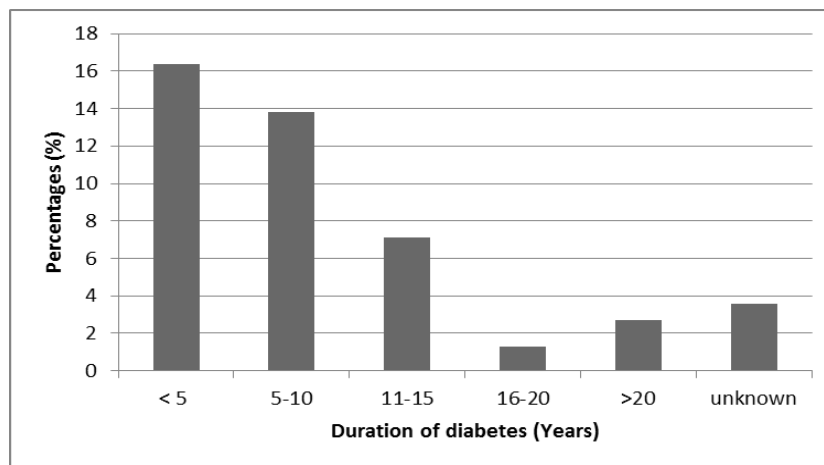


Figure 5.27: Shows the prevalence of visual impairment and blindness according to duration of occurrence of diabetes mellitus.

5.8.2 Knowledge of diabetes types and type of diabetes that the participants had

Many (68.3%) of the participants reported that they did not know the types of DM and 0.9% reported knowing three types of DM (See Table 5.23). When asked the type that they were having, many (67.6%) did not know the type they were having, 28% reported having type 2, and 4.4% reported having type 1. After checking the medical files of the participants, it was found that most (90.1%) of them had type 2 and 9.9% had type 1.

Table 5.23: Shows the number of diabetes mellitus types known, number (N) of participants and percentages. Other refers to those reported knowing more than three types.

Number of types known	Number (N)	Percentages (%)
One type	24	11.4
Two type	40	19
Three types	2	0.9
Other	1	0.5
No type known	144	68.3
Total	211	100

5.8.2.1 *The prevalence of visual impairment and blindness according to the knowledge of diabetes types and type of diabetes*

The prevalence of visual impairment and blindness was 33.7% among participants who did not know any type of DM and 6.6 % among those who knew one type (See Table 5.23). Knowledge of DM types was not significantly associated with visual impairment and blindness ($df=2$, $\chi^2=0.2$, $p=0.920$) (See Table 5.20). The prevalence of visual impairment and blindness among type 1 and type 2 patients

was 4.1% and 40.5%, respectively. Visual impairment and blindness was not associated with the type of DM ($df=1$, $\chi^2=0.1$, $p=0.714$).

Table 5.24: Distribution of the visual impaired/blind and non-visually impaired/blind participants by knowledge of diabetes mellitus types

Number of diabetes types known	Visual impaired/blind N (%)	Not visually impaired/blind N (%)	Total N (%)
1 type	14 (6.6)	10 (4.7)	24 (11.4)
2 types	16 (7.6)	24 (11.4)	40 (19)
3 types	0	2 (0.9)	2 (0.9)
Other	0	1 (0.5)	1 (0.5)
No type known	71 (33.7)	73 (34.6)	144 (68.3)
Total	101 (47.9)	110 (52.1)	211 (100)

5.8.3 Type of treatment/recommendation to control diabetes mellitus

5.8.3.1 Insulin injection

About sixteen percent (15.5%) of the participants used insulin injection to control their DM and 84.6% did not use insulin. Of the 15.5%, 93.1% reported that they always used the treatment as prescribed and 6.9% reported that they did not always use the treatment as prescribed.

a) The prevalence of visual impairment and blindness according to diabetes treatment (Insulin injection).

The prevalence of visual impairment and blindness among the insulin users was 6.7% and 38% among non-insulin users. Visual impairment and blindness was not significantly associated with insulin use ($df= 1$, $\chi^2=0.0$, $p=0.931$) (See Table 5.21).

5.8.3.2 Pills (Tablets)

Most (89.7%) of the participants used pills to control their DM and 10.3% did not use pills. Of the 89.7% who used pills 99.5% reported that they take their treatment as prescribed and only 0.5% reported not taking their treatment as prescribed.

a) The prevalence of visual impairment and blindness according to diabetes mellitus treatment (pills)

The prevalence of visual impairment and blindness among those who used pills was 41.3% and 3.6% among those who did not (See Table 5.25). Use of pills was not significantly associated with visual impairment and blindness ($df=1$, $\chi^2=1.1$, $p=0.306$) (see Table 5.21).

Table 5.25: Distribution of the visually impaired/blind and non-visually impaired/blind participants by diabetes treatment (Pills)

Treatment (Pills)	Visually impaired/blind	Not visually impaired/blind	Total
Yes	92 (41.3)	108 (48.4)	200 (89.7)
No	8 (3.6)	15 (6.7)	23 (10.3)
Total	100 (44.9)	123 (55.1)	223 (100)

5.8.3.3 Special diet

Special diet was recommended to 84.5% of the participants but not to others (15.5%). Of the 84.5%, 71.5% of them reported that they followed special diet as advised and 28.5% reported that they did not always follow a special diet as prescribed.

5.8.3.4 Losing weight

Under half (46.3%) of the participants reported that they were advised to lose weight, but the others (53.7%) were not. Of those who were advised to lose weight, 45.3% reported "Yes, but not

always” when asked whether they were trying to lose weight or not (See Table 5.26).

Table 5.26: Shows the distribution of participants according to their compliance to losing weight

Compliance to losing weight	Number (N) of participants	Percentages (%)
Yes, always	34	29.1
Yes, but not always	53	45.3
Don't lose weight at all	30	25.6
Total	117	100

a) The prevalence of visual impairment and blindness according to the recommendation (losing weight).

The prevalence of visual impairment and blindness was 7.7% among those who answered “yes, always”, (See Table 5.27). There was a significant association between losing weight and visual impairment and blindness ($df= 2$, $\chi^2=9.4$, $p=0.009$) at the 0.1 level of significance .

Table 5.27: Distribution of the visual impaired/blind and not visually impaired/blind versus treatment (compliance to losing weight)

Compliance to losing weight	VI/blind N (%)	Not VI/blind N (%)	N (%)
Yes, always	9 (7.7)	25 (21.4)	34 (29.1)
Yes, but not always	20 (17.1)	33 (28.2)	53 (45.3)
Don't lose weight at all	19 (16.2)	11 (9.4)	30 (25.6)
Total	48 (41)	69 (59)	117 (100)

5.8.3.5 Physical activity

Physical activity was recommended to 62.3% of the participants. Nearly half (48.3%) of them reported “Yes, always” when asked whether they engaged in physical activity or not. Other responses are shown in Table 5.28.

Table 5.28: Shows the distribution of participants according to their compliance to physical activity

Compliance to physical activity	Number (N) of participants	Percentages (%)
Yes, always	70	48.3
Yes, but not always	52	35.9
Don't lose weight at all	23	15.9
Total	145	100

a) The prevalence of visual impairment and blindness according to the recommendation (physical activity).

The prevalence of visual impairment and blindness among those recommended physical activity was 22.7% (See table 5.29). There was a significant association between visual impairment and blindness and physical activity ($df=1$, $\chi^2 = 6$, $p=0.014$) at the 0.1 level of significance. The probability (risk) of those who engaged in physical activity being visually impaired is 0.51 times that of those who did not.

Table 5.29: Distribution of the visual impaired/blind and those not visually impaired/blind versus (physical activity) treatment

Physical activity	Visually impaired/blind	Not visually impaired/blind	Total
Yes	47 (22.7)	82 (39.6)	129 (62.3)
No	42 (20.3)	36 (17.4)	78 (37.7)
Total	89 (43)	118 (57)	207 (100)

5.8.3.6 Health facility used for diabetes services

Most (97.7%) of the participants checked their blood sugar level in public health facilities. About two percent (1.8%) reported that they used private doctors and 0.5% reported that they checked themselves.

5.8.3.7 Last date the participants checked their sugar level

The majority (87.1%) of the participants last checked their sugar level less than 1 month ago (See Table 5.30). There was no association between visual impairment and blindness and the last date participants checked their sugar level ($df=1$, $\chi^2 = 1.4$, $p=0.238$).

Table 5.30: Shows the date for the last sugar level check-up, number (*N*) of participants and percentages (%)

Last check-up	Number (<i>N</i>)	Percentage (%)
< 1 Week ago	5	2.2
< 1 Month ago	195	87.1
< 6 Month ago	23	10.3
<1 year ago	0	0
≥ 1 year ago	1	0.5
Total	224	100

5.8.3.8 Knowledge about the complications of diabetes mellitus

A large percentage (82.6%) reported that they knew that DM could cause vision problems and blindness, 74.4% and 53.1% reported that they knew that DM could cause diabetic retinopathy and glaucoma, respectively (Table 5.31).

Table 5.31: Shows the knowledge of the participants about the diabetes complications

Knowledge of the complications	Vision problems	Diabetic retinopathy	glaucoma
Yes	185 (82.6%)	166 (74.4)	119 (53.1)
No	39 (17.3%)	58 (25.9)	105 (46.9)
Total	224	224	224

a) Knowledge about the complications of diabetes as a risk factor for visual impairment and blindness

Visual impairment and blindness was not significantly associated with knowledge of DM and its complications (for vision problems and blindness, $df=1$, $\chi^2=0.8$, $p=0.359$; for diabetic retinopathy, $df=1$, $\chi^2=0.3$, $p=0.601$; for glaucoma, $df=1$, $\chi^2=0.0$, $p=0.973$).

5.8.4 History of eye examination

Nearly half (49.3%) of the participants reported that they have had their eyes examined by an ophthalmologist or an optometrist. Just over forty percent (45.4%) were last examined a year and longer ago (Table 5.32).

Table 5.32: Shows the date for the last eye examination, number (N) of participants and percentages (%)

Last eye examination	Number (N)	Percentage (%)
< 1 Week ago	0	0
< 1 Month ago	13	10.9
< 6 Month ago	19	16
< 1 year ago	16	13.5
≥ 1 year ago	54	45.4
Unknown	17	14.3
Total	119	100

5.8.4.1 History of eye examination as a risk factor for visual impairment and blindness

The prevalence of visual impairment and blindness among those who have had the eyes examined and those who have never been examined was 24% and 20.7%, respectively. There was no significant association between history of eye examination and visual impairment and blindness ($df=1$, $\chi^2 = 1.3$, $p=0.255$) .

The prevalence of visual impairment and blindness was the highest (21.9%) among those who were last examined over a year ago (See Table 5.33). There was a significant association between date of the last eye examination and visual impairment and blindness ($df=4$, $\chi^2 = 9.1$, $p=0.059$)

Table 5.33: Distribution of the visual impaired/blind and non-visually impaired by last date of eye examination

Last eye examination	Visually impaired/blind <i>N</i> (%)	Not visually impaired/blind <i>N</i> (%)	Total <i>N</i> (%)
< 1 Week ago	0	0	0
< 1 Month ago	1 (0.8)	12 (10)	13 (10.9)
< 6 Month ago	11 (9.2)	8 (6.7)	19 (16)
< 1 year ago	8 (6.7)	8 (6.7)	16 (13.5)
≥ 1 year ago	26 (21.9)	28 (23.5)	54 (45.4)
Unknown	7 (5.9)	10 (8.4)	17 (14.3)
Total	53 (66	119

5.8.5 Family history of diabetes mellitus

Over half (52.7%) of the participants had family history of DM and 37.7% did not. About ten percent (9.6%) were not sure if they had family history of DM or not. When asked if any of the family members with DM had visual impairment, 31.6%, 53.2% and 15.2%, answered “yes”, “no”, “not sure”, respectively. There was no association between visual impairment and blindness and family history of DM ($df=2$, $\chi^2 = 2.4$, $p=0.305$).

5.8.6 Hypertension among the participants

Many (78.8%) of the participants had hypertension and most (92.7%) of them last checked their BP less than 1 month ago (See Table 5.34). Almost all (98.8%) of them were on medication (tablets) and

took it as prescribed. With regard to compliance to the other recommendation (physical activity, special diet, losing weight, etc.), the results are similar to those discussed above.

Table 5.34: Shows the date for the last blood pressure check-up, number (*N*) of participants and percentages (%)

Last BP check-up	Number (<i>N</i>)	Percentage (%)
< 1 Week ago	8	3.6
< 1 Month ago	204	92.7
< 6 Month ago	6	2.7
<1 year ago	1	0.5
≥ 1 year ago	1	0.5
Total	220	100

5.8.6.1 Hypertension as a risk factor for visual impairment and blindness

The prevalence of visual VI and blindness among people with DM with and without hypertension was 35.5% and 8.6%, respectively. However, visual impairment and blindness was not significantly associated with presence of hypertension among the participants ($df=1$, $\chi^2=0.2$, $p=0.652$).

5.8.7 Smoking status among the participants

Most (80.6%) of the participants had never smoked cigars, cigarettes, or pipe of tobacco. Other categories of smoking status are shown in Figure 5.28. .

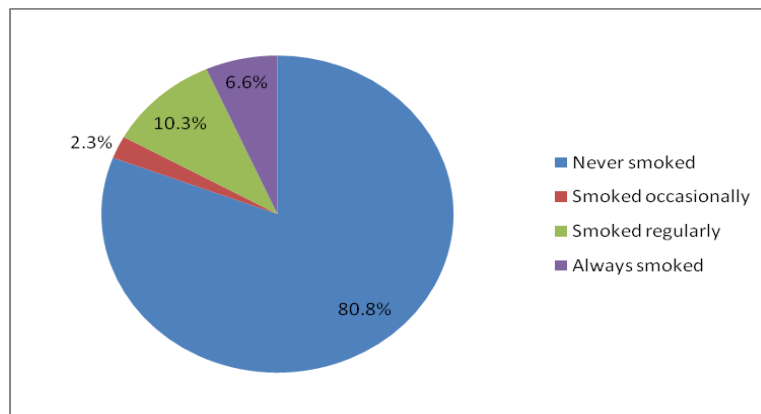


Figure 5.28: Shows the distribution of participants according to their smoking status

5.8.7.1 Smoking status as a risk factor for visual impairment and blindness

The prevalence of visual impairment and blindness among participants who never smoked, smoked occasionally, smoked regularly and always smoked was 37.1%, 3.3%, 0% and 5.2%, respectively. There was no significant association between visual impairment and blindness and smoking status ($df=3$, $\chi^2=4.4$, $p=0.214$) (See Table 5.21).

a) Age when participants when started smoking

Many (24.4%) of the participants started smoking below the age of 20 years. A few (4.9%) of them started between the age of 30 and 34 years (Table 5.35). there was no association between visual

impairment and blindness and age when they started smoking ($df=4$, $\chi^2 = 2.4$, $p=0.660$)

Table 5.35: Shows the number (N) and percentages (%) of participants by age when they started smoking

Age (Years)	Number (N)	Percentage (%)
<20	10	24.4
20-24	6	14.6
25-29	6	14.6
30-34	2	4.9
35 and older	6	14.6
Unknown	11	26.8
Total	41	100

b) Frequency of smoking among the participants

Many (56.1%) of the participants had quit smoking and a few (9.8%) were smoking regularly (Figure 5.29). Most (96.4%) of those who quit did so longer than a year ago, the others (3.6%) were not sure about when they quit smoking.

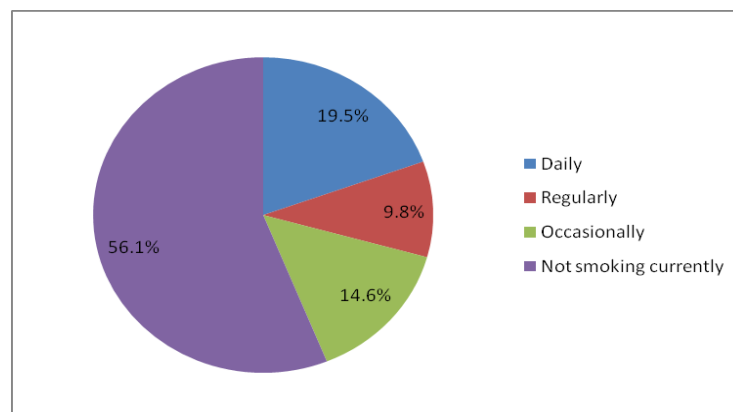


Figure 5.29: Shows the distribution of participants according to their smoking frequency

5.8.8 Accessibility of the public health facility

For many (37.4%) of the participants, public health facilities were located less than 30 minutes walk from their homes (See Figure 5.30).

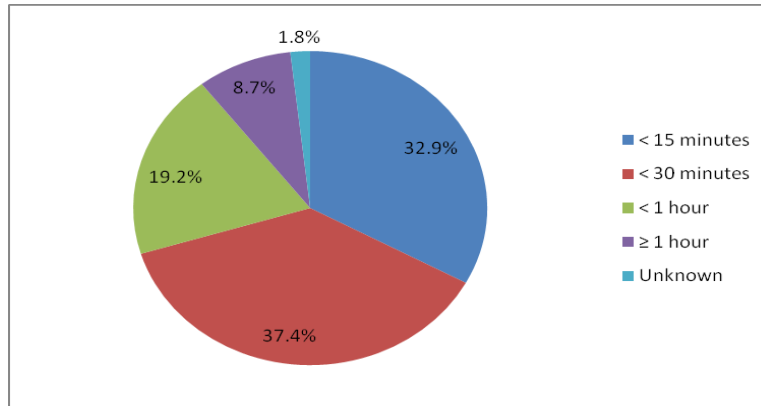


Figure 5.30: Shows the distribution of the participants according to their accessibility to public health facilities

5.8.8.1 Accessibility of the public health facility as a risk factor for visual impairment and blindness

Sixteen percent (16%) and 3.2% of those who walked for <30 minutes and for > 1 hour from their homes to the health facility, respectively, had visual impairment and blindness (Figure 5.31). There was no significant association between visual impairment and blindness and accessibility to public health facility ($df= 4$, $\chi^2 = 2.2$, $p=0.9634$) .

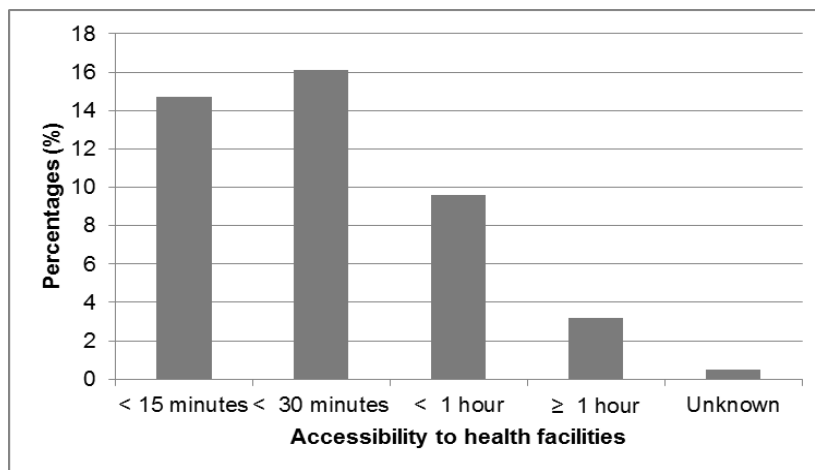


Figure 5.31: Shows the prevalence of visual impairment and blindness according to accessibility to public health facilities

5.8.9 Logistic regressions of the prevalence of visual impairment and blindness on the risk factors

5.8.9.1 Risk factors that jointly affect uncorrected visual impairment and blindness

The risk factors that were individually associated with visual impairment and blindness at the 0.1 level of significance include educational qualification, monthly income, knowledge of DM types, oral treatment of DM (pills), losing weight, compliance to losing weight and family history of DM. However, when the Proc Logistic in

SAS (Statistical Analysis System) Version 9.2 was used to fit logistic models for the above variables, four factors remained significantly associated (at the 0.1 level of significance) with visual impairment and blindness in the presence of other factors. These include knowledge of DM types, oral treatment of DM (pills), compliance to losing weight and family history of DM (see Table 5.36). Educational qualification, monthly income and losing weight were not associated with visual impairment and blindness in the presence of other factors, because of the association among the risk factors that individually affect visual impairment and blindness. The following pairs of risk factors were associated with each other: knowledge of DM types and educational qualification; knowledge of DM types and monthly income; educational qualification and family history; losing weight and compliance to losing weight; family history and monthly income.

Table 5.36: Shows the risk factors that jointly affect uncorrected visual impairment and blindness, degree of freedom (*df*), chi-square (χ^2), *p*-value and conclusion

Risk factors	<i>df</i>	χ^2	<i>p</i>-value	Conclusion
Knowledge of DM types	2	8.038	0.045	Significant
Oral DM treatment	1	5.132	0.077	Significant
Compliance to losing weight	2	10.088	0.0178	Significant
Family history of DM	2	8.918	0.030	Significant

5.8.9.2 Risk factors that jointly affect corrected visual impairment and blindness

The risk factors that were individually associated with visual impairment and blindness at the 0.1 level of significance include

age, monthly income, physical activity, losing weight, and date of last eye examination. However, when the Proc Logistic in SAS (Statistical Analysis System) Version 9.2 was used to fit logistic models for the above variables, only two factors namely: monthly income and physical activity remained significantly associated (at the 0.1 level of significance) with visual impairment and blindness in the presence of other factors (see Table 5.37). Age, losing weight and last eye examination were not associated with visual impairment and blindness in the presence of other factors, because of the association among the risk factors that individually affect visual impairment and blindness. The following pairs of risk factors were associated with each other: age and monthly income; losing weight and physical activity; physical activity and monthly income.

Table 5.37: Shows the risk factors that jointly affect corrected visual impairment and blindness, degree of freedom (*df*), chi-square (χ^2), *p*-value and conclusion

Risk factors	<i>df</i>	χ^2	<i>p</i>-value	Conclusion
Monthly income	4	10.753	0.029	Significant
Physical activity	2	14.963	0.001	Significant

“Significant” means that the factor is associated (at the 0.1 level of significance) with visual impairment and blindness variable in the presence of other factors.

5.9 CONCLUSION

The results obtained from vision examination, anthropometric measurements and interviews in this study were presented in this chapter. Over half (54.7%) of the participants were 60 years and older and there were more females (71.5%) than males (28.4%) in this study. Only 12% of the participants were wearing optical correction. Before optical correction, the prevalence of visual impairment and blindness in the right eyes of the participants was 70.7% and 3.6%, respectively. However, after optical correction, the prevalence of visual impairment decreased to 41.3% and that of blindness remained the same at 3.6%. Many of those who were visually impaired had moderate visual impairment. Before optical correction, the prevalence of visual impairment and blindness was significantly associated with educational qualification and monthly income. However, after optical correction, the prevalence of VI and blindness was significantly associated with age, monthly income, physical activity, weight loss compliance and last eye examination.

The leading causes of visual impairment and blindness before optical correction were refractive errors (49.5%) and cataract (24.7%). However, after optical correction the leading causes were cataract (76.8%) and diabetic retinopathy (7.1%). Diabetic retinopathy was not found in participants below the age of 55 years. About 40% of the participants had DM for less than 5 years and about 70% did not know any type of diabetes. Most (90.1%) of the participants had type 2 DM and only 9.9% had type 1. The prevalence of VI and blindness was high among those with type 2 (40.5%) than among those with type 1 DM (4.1%). Almost all (97.7%) of the participants used public health facilities for their diabetes check-up and most of them last checked their blood sugar level less than a month ago. Of the 49.3% of those who ever had their eyes examined by an optometrist or ophthalmologist, 45.4% were last examined longer than a year ago. The prevalence of VI and

blindness was highest among those who were last examined longer than a year ago. Many (78.8%) of the participants had hypertension and the prevalence of VI and blindness was 35.5% among those with hypertension and 8.6% among those without the condition. Many (37.4%) of the participants lived less than 30 minutes walk to the public health facilities.

CHAPTER 6

DISCUSSION, LIMITATIONS, RECOMMENDATIONS AND CONCLUSION

6.1 INTRODUCTION

The results obtained from vision examination, anthropometric measurements and interviews in this study were presented in chapter 5. The number of the participants per public health facility (Clinics, health centre, and hospitals) was presented (5.2) in that chapter. The distribution of the participants by the various socio-demographic characteristics (age, gender, marital status, etc) as well as by the anthropometric measurements (Body Mass Index and waist circumference) was presented in section 5.3. The prevalence and distribution of visual impairment (VI) and blindness [(based on both presenting and aided visual acuity (VA)] as well as their relationship to the various socio-demographic and anthropometric characteristics were presented in sections 5.4 and 5.5. Further, the causes of VI and blindness before and after optical correction were also presented in section 5.6 and 5.7. In this study, visual impairment was defined as $VA < 6/9.5$ to $\geq 3/60$, and blindness as $VA < 3/60$ (Table 4.1). According to the WHO (2011), visual impairment is defined as $VA < 6/18$ to $\geq 3/60$, and blindness as $VA < 3/60$ (Table 1.1). The clinical risk factors of visual impairment and blindness were presented in section 5.8.

As indicated in chapter 1, the research design in this study was health facility-based, quantitative, descriptive, and cross-sectional in nature. The study population consisted of Black South African diabetic adults of both sexes, who were 40 years and older in Mopani District of the Limpopo Province. A sample of 225 people with DM who met the inclusion criteria participated in this study.

The aim of this study was to determine the prevalence and causes of visual impairment and blindness among Black South African diabetic adults who are 40 years and older in Mopani District, Limpopo province. In addition, the study sought to determine the relationship between risk factors for visual impairment or blindness among people with DM. The research objectives for this study were to:

- i. Determine the prevalence of visual impairment or blindness among the Black South Africans with DM who are 40 years and older in Mopani District, Limpopo Province.
- ii. Determine the causes of visual impairment or blindness among the Black South Africans with DM who are 40 years and older in Mopani District, Limpopo Province.
- iii. Describe the risk factors that are associated with visual impairment or blindness among the Black South Africans with DM who are 40 years and older in Mopani District, Limpopo Province.

In this chapter, the results presented in chapter 5 are discussed. At the beginning of this chapter, a historical overview of the current health care system in South Africa is presented. This is followed by a brief discussion of the research setting, the number of participants per health facility and the demography and anthropometric measurements of the participants. The prevalence of visual impairment and blindness based on presenting VA is discussed. In addition, the prevalence based on corrected visual acuity is presented, and then these were discussed in relation to the various socio-demographic characteristics and the anthropometric measurements. Further, a discussion of the causes as well as the clinical risk factors of VI and blindness is presented in this chapter. Lastly, the limitations and contributions of the study as well as recommendations are presented.

6.2. A HISTORICAL OVERVIEW OF HEALTH CARE SYSTEM IN SOUTH AFRICA

The history of South Africa has a significant effect on the current health care system and the health of South Africans. In 1994, South Africa became a democratic country, but before this period, the apartheid policy structured the society according to race and gender. This greatly influenced the entire social system and the access to basic health resources and services. One of the most important influences on the health of South Africans has been the impoverishment of the Black population in the face of the general White people affluence (Coovadia, Jewkes, Barron, Sanders & McIntyre 2009). In the late 19th and 20th centuries, low wages, overcrowding, inadequate sanitation, malnutrition caused the health of the Black population to deteriorate (Packard 1989). The deliberate under-education of the Black population through the system of Bantu education worsened the rate of unemployment and poverty among the Black population and hence an increase in the burden of poverty-related diseases (Coovadia *et al* 2009)

As early as the 17th century, a notable feature of the history of health services in South Africa has been fragmentation, both within the public sector and between the public and the private sector. The health facilities were racially segregated and curative and preventive services were separated (Coovadia *et al* 2009). Prior to 1994, the Apartheid system necessitated the fragmentation of health care into 14 health departments comprising the then 4 provinces of South Africa (Cape Province, Natal, Orange Free State and Transvaal), the four homelands (Transkei, Bophuthatswana, Venda and Ciskei) as well as 6 “self-governing” territories (Gazankulu, KaNgwane, KwaNdebele, KwaZulu, Lebowa and Qwaqwa) (South African Human Rights Commission 2009). The health departments in the homelands/Bantustans (impoverished rural areas where African Blacks were involuntarily restricted to during the apartheid era), which focussed mainly on the hospital sector, were systematically

underfunded, poorly organised, inefficient and often ineffectively managed and these resulted in high levels of ill health and mortality in these areas (Coovadia *et al* 2009, Kautzky & Tollman 2008).

To further complicate this fragmentation, within the provincial health departments there were separate services for each racial group (Black, Coloured, Indian and Whites), with most of the health budget being allocated to Whites, thus providing them with better access to health services than the other racial groups. This racially based allocation of the budget severely compromised the ability of Blacks to access public health care services, with disastrous consequences in most cases (South African Human Rights Commission 2009).

In 2012, eighteen years after the end of apartheid, the democratically elected government is still grappling with the legacy of apartheid and the challenges of addressing the disempowerment, discrimination, and underdevelopment of the health care system (Coovadia *et al* 2009). Despite the challenges, the new government has managed to consolidate the 14 health care administrations of the Bantustans and South Africa into one national and nine provincial health departments (Coovadia *et al* 2009). The public health care system has been transformed into an integrated and comprehensive national service, with the goal of redressing the historical inequities and to provide essential health care to the disadvantaged people. The government has built 1,345 new clinics and upgraded 263, which improved the accessibility and availability of health services to the entire South Africans (Coovadia *et al* 2009).

Despite these successes, the South African health system is still inequitable, with the privileged few having disproportionate access to health services. Health services availability, accessibility and affordability are still biased towards the wealthy minority who use the private sector, which receives the substantial share (60%) of the health expenditure (McIntyre 1995). It is estimated that only 17% of

the population are members of the medical schemes and 23% use the private sector on the regular basis (McIntyre 1995). In addition, health services are still biased towards the historically “White” areas as certain geographic areas such as the rural areas, particularly former homelands, township, and informal settlements were systematically underfunded as a result of apartheid policies. For instance, the per capita public sector expenditure, 1992/93 was 3.5 times greater in most well-resourced provinces compared to the least well-resourced province (McIntyre & Gilson 2002:1640).

These have prompted the government to introduce the National Health Insurance (NHI) that is intended to ensure that all South Africans regardless of their socioeconomic status have access to appropriate, efficient and quality health services. The broad objective of the NHI is to put into place the necessary funding and health service delivery mechanisms, which will enable the creation of an efficient, equitable and sustainable health system in South Africa. It will be based on the principles of the right to health, social solidarity and universal coverage. The NHI is expected to be phased-in over 14 years (Department of Health 2011). It remains to be seen whether this intervention will bring about the envisaged equity in the health care services in the country.

6.3 RESEARCH SETTING

As indicated earlier in chapter 4, this study was conducted in seven public health facilities in the Mopani District, Limpopo Province. Five of the seven public health facilities are located in the Greater Tzaneen Local Municipality and the other two facilities are located in the Greater Letaba Local municipality (4.2). Limpopo Province has an estimated total population of 5.2 million people. This figure is about 11% of the national population. Limpopo province has seven district municipalities including the Mopani District Municipality. This municipality is situated in the North-eastern part of Limpopo Province, 70km and 50km from Polokwane (The provincial capital),

along the provincial roads R81 and R171, respectively. It shares borders with Mozambique in the East, Zimbabwe and Vhembe District Municipality in the North, Mpumalanga Province through Enhlazeni District Municipality in the South, Capricorn District Municipality in the West and Sekhukhune District Municipality in the South-west (Mopani District Municipality 2009).

The population of the Mopani District is estimated at 1.1 million, with 81% residing in the rural areas, 14% in urban areas and 5% in the farms. Of the total population, 54% are females and 46% are males. Over 50% of the adult population are regarded as being functionally illiterate (Mopani District Municipality 2009). Approximately 73% of the population is unemployed and of this percentage, about 60% are women. The largest employer in the district is the government, followed by the farming sector (Mopani District Municipality 2009).

During the 2008/9 period, Mopani District had 99 clinics, 9 health centres, and 9 hospitals altogether serving about 248254 people [Statistics South Africa (Statssa) 2007]. The clinics and health centres are the first point of entry to health services for South Africans. Health services that are provided in the clinics include treatment of minor ailments, family planning services, immunisations of babies, management of chronic diseases such as DM, hypertension, etc. Clinics are normally opened for only eight hours a day. Some clinic staff may however be expected to sleep at or near the hospital so that they are available in case of emergency (Cullinan 2006). Health centres normally provide 24-hour maternity and emergency services, in addition to all services rendered in the clinics. A Health centre has a minimum of 30 beds where patients can be observed for a maximum of 48 hours. From April 1996, services in the clinics and health centre were free of charge. A hospital normally provides health services to patients who need in-patient care, although all have outpatient departments (OPD) (where

patients with minor ailments who do not need in-patient care are treated by doctors) and casualty or emergency care (Cullinan 2006).

The prevalent diseases in the Mopani District include diarrhoea, pneumonia, tuberculosis, HIV and AIDS, malaria, cholera and sexually transmitted infections. According to a survey conducted on women attending antenatal clinics in 2002, Mopani had the highest (23.1%) prevalence of HIV infections in the Province (Statssa 2004). This may be due to lack of access to information about HIV/AIDS among the people, especially migrant farm workers who come from the neighbouring countries (International Organization for Migration (IOM) 2009). About 10,253 people have been reported to be visually disabled (causes of visual disability not specified) (Statssa 2007).

6.4 NUMBER OF PARTICIPANTS PER HEALTH FACILITY

A large number of participants were selected from Letaba hospital (28.9%) (Table 5.1). One reason for this may be that the research team visited this hospital three times to collect data, and in each visit there were more patients compared to those found in other health facilities. The other reason may be that historically, diabetes management services were available only in hospitals (Cullinan 2006) and as one of the well established hospitals in the area people still prefer using the Letaba hospital for their diabetes check-up. The other reason is that people allege that they frequently do not find their treatment in the clinics; hence, they prefer Letaba hospital because they always get their treatment in that hospital.

6.5 DEMOGRAPHY AND ANTHROPOMETRIC MEASUREMENTS OF THE PARTICIPANTS

6.5.1 Age distribution of the participants

A large number of participants in this study were in the older age group (Table 5.2) presumably because older age groups, especially

those living in the rural areas are more likely to utilise the public health services than the younger age groups. The reason for this might be that the majority of older people in the rural areas are poor and therefore cannot afford private health services. In contrast, participants in the younger age groups are likely to be economically active and may have been at their workplaces during the time of the study. In addition, many of them may be members of medical schemes and could therefore afford private health services. This might explain the lower percentage of participants in the younger age groups than in the older age group. The other reason may be that the prevalence of DM increases with increasing age.

The high proportion of participants in the older age group in this study agrees with the finding from other studies in the country. In the study in Durban, South Africa to assess the level of diabetic patients' knowledge of diabetes mellitus, its complications and management among 106 participants aged 30 years and older, many (67%) of the participants were in the elderly population between 50 and 69 years (Mashige, Notshweleka, Moodley, Rahmtoola, Sayed, Singh & Sardiwalla 2008:98). In a study in the Western Cape, South Africa to investigate the diabetic patients' knowledge and its complications among 98 people with DM aged 30 years and older, high proportion (69%) of the participants were also found to be between 50 and 69 years old (Clarke-Farr, Nel & Wilkinson 2006:137).

In a study in South-western Nigeria to assess the prevalence and factors influencing previous dilated eye examination in screening for retinopathy among 83 type 2 patients aged ≥ 16 years old, most (85.5%) of the participants were also found to be between 45-64 years (Onakpoya, Adeoye & Kolawole 2010:177). This further agrees with findings from the present study where a high proportion of participants were found in the older age group. As stated above, the high proportion of participants in the older age group, suggest that the incidence of DM increases with increasing age.

6.5.2 Distribution of the participants by gender

The fact that there were more females (71.5%) than males (28.4%) in this study is consistent with the South African demographics as well as those of the Mopani District as stated above. This is also consistent with the findings in other South African studies. In a study in Durban, South Africa to assess the level of diabetic patients' knowledge of diabetes mellitus, its complications and management among 106 participants aged 30 years and older, females (65%) were more than males (35%) (Mashige *et al* 2008:98). In a study in the Western Cape, South Africa to investigate the diabetic patients' knowledge and its complications among 98 people with DM aged 30 years and older, females (72%) were more than males (28%) (Clarke-Farr *et al* 2006:137). However, in another study in Cape Town to evaluate the knowledge about the diabetes, its ocular effects and management protocols among 73 people with DM aged 33 years and older, males (59%) were more than females (41%) (Phillips, Mashige & Clarke-Farr 2012:72). This may be because of the small sample size and that the participants were selected from an optometric practice.

The fact that there were more females than males is also consistent with findings from studies in other countries. In a study in Kinmen, Taiwan to assess the prevalence and associated factors of cataract surgery among patients with type 2 DM, females (59.7%) were more than males (40.3%) (Tsai, Tung, Woung, Liu, Lee, Shih, Chen & Chou 2007:264). In some African studies, females were also more than males. In a study carried out across six sub-Saharan African countries to evaluate DM control, management and late complications among 2352 with type 2 DM, females (61.1%) were also more than males (38.9%) (Sobngwi, Ndour-Mbaye, Boateng, Ramaiya, Njenga, Diop, Mbanya & Ohwovoriole 2012:32). In a study in Southwestern Nigeria, 61.4 % were females and 38.6% were males (Onakpoya *et al* 2010:177). The fact that there were more

females than males in the present study is consistent with the report that worldwide, there are more females than males with DM (King *et al* 1998: 1416).

6.5.3 The distribution of the participants by marital status

The higher proportion of the married participants (55.1%) in this study (Table 5.3) is in agreement with the report of the South African population census 2001, which showed a higher (34%) percentage of married people than those who were divorced (1.6%) (Statssa 2004). This may be a reflection of the marital engagements of the people living in the Mopani district of the Limpopo province.

6.5.4 The distribution of the participants according to occupations

Many (60.4%) of the participants in this study were pensioners. This is consistent with findings from other studies. In a study in Durban, South Africa, most (45%) of the participants were pensioners, 26% were housewives, 22% formally employed and 7% were unemployed (Mashige *et al* 2008:98). In a study in Cape Town, the largest category of the participants (32%) were pensioners, 23% were housewives, 23% indicated some other type of employment and 11% were unemployed (Clarke-Farr *et al* 2006:137). The higher proportion of pensioners is expected as almost 70% of the participants in these studies were 50 years and above.

6.5.5 The distribution of the participants according to ethnic groups

The finding that over half (53.8%) of the participants were of the Sotho ethnic group (Figure 5.3) agrees with the report from the population census that 52.1% of the population in the Limpopo province were Sotho-speaking (Statssa 2004).

6.5.6 The distribution of the participants according to educational qualifications

With regard to educational status, many (41.3%) of the participants in this study had only primary education and a few (6.7%) had tertiary education. The percentage (41.3%) of participants with primary education in this study was higher than the 13.7% reported for the Mopani District as a whole (Mopani District Municipality 2009). In addition, the 6.7% of those with tertiary education in this study was slightly higher than the 6.5% reported for the district (Mopani District Municipality 2009). Contrary to the findings in this study, the proportion of those with primary education in a study in Cape Town (Phillips et al 2012:72) was 4.1% and those with tertiary education was 31.5%. The reason for the differences may be due to differences in the population studied and the study sites. Many of the participants in the Cape Town study (Phillips et al 2012:72) were Coloured (59%) or were White (38%) and only 3% were Black. In contrast, all the participants in this study were Black.

During the apartheid era, Blacks were deliberately undereducated through the system of Bantu education and the Coloured and White people had better education than the Black people did. In addition, Cape Town has been one of the well-resourced provinces when compared with provinces like the Limpopo Province, which has been grossly underfunded during the apartheid years (Coovadia *et al* 2009). The fact that the majority of the participants in the Cape Town study were Coloured and White people and those in this study were Black people may explain the differences in the educational qualifications.

6.5.7 The distribution of the participants according to the monthly income and the source of household income

It was expected that many (69%) of the participants in this study would be earning R2000 or less as the majority of them were

pensioners (Figure 5.5). As from April 2012, the government pays about R1200 to people who qualify for old-age pension (South African Government services 2012). The source of household income of many (61.3%) of the participants was old-age pensions.

6.5.8 The distribution of the participants according to place of the residence

It was also expected that many (68.9%) of the participants would be from the rural areas (Figure 5.7) since about 80% of the population in the Limpopo province live in the rural areas (Limpopo DHSD 2011) and most (81 %) of the residents of the district live in the rural areas (Mopani District Municipality 2009).

6.5.9: The distribution of body mass index and waist circumference of the participants

Obesity is becoming a major public health problem in many developing countries, including South Africa. This may be attributed to among other factors, urbanisation, decreased physical activity, and replacement of traditional nutritious diets with western-style diets (IDF 2006). In a study in South Africa to ascertain the anthropometric profile and determinants of obesity in South Africans aged ≥ 15 years who participated in the Demographic and health Survey in 1998, the mean BMI values for men and women were 22.9 kg/m² and 27.1 kg/m², respectively.

For men, 29.2% were overweight or obese (≥ 25 kg/m²), whereas for women 56.6% were overweight or obese. Higher levels of BMI were found in older men, who lived in the urban areas and who higher levels of education. For women, higher BMI levels were found in those who were older than in those who were younger, those living in urban areas than those in non-urban areas and African women, who had significantly higher BMI than all other groups (Puoane,

Steyn, Bradshaw, Laubscher, Fourie, Lambert & Mbananga 2002:1041).

In another Demographic and Health Survey in South Africa in 2003 (Department of Health, Medical Research Council, OrcMacro 2007) among persons aged ≥ 15 years, the mean BMI levels (27 kg/m^2 , for women and 23 kg/m^2 , for men) were similar to those reported in the above study. The percentage (29.8%) of men who were overweight or obese ($\geq 25 \text{ kg/m}^2$), was also similar to the 29.2% reported in the above study. however the percentage (54.9%) of the overweight or obese women was lower than that reported in the above study

In this study, BMI measurements were taken from only 200 participants, comprising 60 males and 140 females. This is because some participants had to leave early for doctor's appointment, to go and fetch children from preschools, etc. The mean BMI levels for women ($30.5 \pm 5.31 \text{ kg/m}^2$) and men ($27.9 \pm 4.9 \text{ kg/m}^2$) in this study were higher than what was reported in the above two South African Demographic and Health Surveys (Puoane *et al* 2002:1041, (Department of Health, Medical Research Council, OrcMacro 2007). However, these values were lower than those reported in a South African study among 253 diabetic patients aged 21-81 years. In this study the mean BMI was 31.2 kg/m^2 , and that for women and men was 32 kg/m^2 and 29.1 kg/m^2 , respectively (Rotchford & Rotchford 2002:538).

In a study to estimate the population attributable fraction of elevated BMI for diabetes mortality by country, sex and age group for the Western Pacific and South-East Asia regions, the mean BMI varied by country, sex and age. For women, the mean BMI ranged from $20.5 \pm 7.7 \text{ kg/m}^2$ in India to $36.2 \pm 5.1 \text{ kg/m}^2$ in American Samoa. For men, it ranged from $20.2 \pm 5.91 \text{ kg/m}^2$ in India to $33.7 \pm 7.81 \text{ kg/m}^2$ in American Samoa (Martiniuk, Lee, Colaguirri & Woodward 2011:472). For both women and men, the mean BMIs ($30.5 \pm 5.31 \text{ kg/m}^2$ and $27.9 \pm 4.9 \text{ kg/m}^2$, for women and men) in the present study are higher

than what was reported for India, but lower than those reported for American Samoa, in the above study. The reason for the differences may be due to differences in the populations studied and the methodologies.

The prevalence of overweight (BMI, 25-29.99kg/m²) among women was similar to that among men (38 versus 37%), however the percentage of those with obesity (≥ 30 kg/m²) was higher among women than among men (49 versus 32%). The fact that the prevalence of obesity was higher among the women than among men agrees with what was reported in other studies. In a study in India to report the prevalence of obesity indices among 1414 people with DM and to determine their association with DR, obesity defined by just BMI (≥ 23 kg/m²) and waist circumference (≥ 90 cm in men and ≥ 80 cm in women) was more prevalent in women than in men (Raman, Rani, Gnanamoorthy, Sudhir, Kumaramanikavel & Sharma 2010:211). Data from the South African demographic and health survey 2003 showed that women had high prevalence of obesity than men (27.4 versus 8.8%) (Department of Health, Medical Research Council, OrcMacro 2007).

In a study in China to compare the magnitude of the association between 2 years change of WC or BMI and incident type 2 DM, 2 years change of waist circumference (WC) was positively associated with risk of type 2 DM after adjustment for some other factors, no matter whether the participants had abdominal obesity at baseline or not. Two years change of WC was a better predictor for type 2 DM than that of BMI change (Luo, Guo, Hu, Zhou, Wu, Zhang, & Liu. 2012: xxx.e3). However, in a study in Iran to compare the ability of the BMI, WC, waist-to-hip ratio (WHR) and waist-to-stature ratio (WSR) to predict progression to diabetes in 704 non-diabetic first-degree relatives of type 2 patients aged 20-70 years, all three obesity indicators (BMI, WC, WSR) had similar associations with incident diabetes (Janghorbani & Amini 2010:e28). In this study, waist circumference ranged from 72 to 203cm with a mean of

107±15cm, indicating substantially increased risk of diseases of lifestyles (WHO 2004c).

6.5.10: The number of participants wearing spectacles

Only 12% of the participants in this study wore spectacles. The expectation was that a larger percentage of participants would be wearing spectacles since this study was done among those who were 40 years and older, but that was not the case. This suggests that there is a great need to improve the availability, accessibility and affordability of optometric services, particularly in the rural areas of the Limpopo Province.

6.6 THE PREVALENCE OF VISUAL IMPAIRMENT AND BLINDNESS AMONG THE PARTICIPANTS

Several authors have reported the prevalence of visual impairment and blindness in diabetic patients and the findings vary from one study to another. Findings in this study were compared with some of these previous studies and an attempt was made to offer possible reason/s for differences or similarities. The prevalence of visual impairment (VI) and blindness in this study was determined based on both the presenting visual acuity (PVA) and aided visual acuity (AVA). To briefly recapitulate, presenting visual acuity refers to visual acuity measured with habitual optical correction (for those using optical correction) or without any optical correction (for those not using optical correction). Aided visual acuity refers to acuity measured with the participant wearing a trial frame with lens prescription obtained from auto-refraction results; where necessary, a pinhole is placed over the trial lenses when measuring the AVA.

The reason for determining the prevalence based on PVA was to be able to report the prevalence of VI due to refractive errors, which has been found to be the leading cause of VI (WHO 2012). Defining VI and blindness based on best corrected visual acuity (BCVA) has

been found to overlook a large proportion of persons with VI and blindness due to uncorrected refractive errors, which is more prevalent in many parts of the world (WHO 2012). The reason for determining VI and blindness in terms of the AVA was to be able to compare the findings in this study with the previous studies that used best corrected VA to classify visual impairment and blindness. In view of these two methods of determining visual impairment and blindness, the findings based on the two methods of determination will be discussed in this study.

According to the researcher's knowledge, this is the first report on the prevalence and causes of visual impairment and blindness among persons with DM in South Africa. The prevalence of visual impairment based on both presenting and aided visual acuity in the right eyes was 70.7% and 41.3%, respectively and in the left eyes, it was 72% and 42.2% respectively. The prevalence of blindness in the right and left eyes was 3.6% (for both PVA & AVA) and 3.1% (for both PVA & AVA), respectively. Moderate visual impairment was more common in both the right and left eyes of the participants (Tables 5.4, 5.5, 5.8 & 5.9). This is because moderate VI category is greater than the mild or the severe VI categories. The moderate VI category spans 0.5 logMAR (magnitude) while mild or severe VI only spans 0.3 logMAR.

A two-sided paired t-test was used to compare the means of the visual acuities (VA's) of the right and left eyes. The results (t -value=0.47 with $df=224$, $p=0.638$) at the 0.1 level of significance showed that there was no significant difference between the means of the VA's of the two eyes. Therefore, unless stated otherwise, the results discussed hereunder are those from the right eyes of the participants. The use of data from the right eye is in keeping with previous studies. Data from the right eyes were used in a study in Bangladesh to determine the prevalence of refractive errors and to investigate factors associated with refractive error in adults 30 years of age and older (Bourne, Dineen, Ali, Noorul Huq & Johnson 2004).

Data from the right eye were also used in Nigeria in a study to provide data on the prevalence and types of refractive error and the spectacle-wearing rate among adults (Ezelum, Razavi, Sivasubramanian, Gilbert, Murthy, Entekume, Abubakar, Nigerian National Blindness & Visual impairment Study Group 2011).

In contrast, other studies used data from the better eye. Data in the better eye were used in a study in New Jersey to determine the frequency and severity of diabetic retinopathy as well as associated visual impairment (Roy 2000). Data from the better eye were also used in a study in the United Kingdom to provide estimates of VI among people with DM attending screening in a multi-ethnic population (Sivaprasad, Gupta, Gulliford, Dodhia, Mann, Nagi & Evans 2012). In a study in Hong Kong to determine the proportion of visual impairment than could be corrected with prescription spectacles among the diabetic population, data from the better eye were also used (Fung, Yap & Cheng 2010).

6.6.1 Prevalence of visual impairment and blindness based on presenting visual acuity

Several authors have presented the prevalence of visual impairment based on presenting visual acuity (PVA) as was done in an aspect of this study. In the present study, the prevalence of visual impairment ($VA < 6.9.5$ to $\geq 3/60$) and blindness ($VA < 3/60$) based on the PVA is considerably higher (70.7% for VI and 3.6% for blindness) than that reported by other authors. A lower (11%) prevalence of visual impairment ($VA < 6/12$ to $\leq 6/60$) was reported in a study in the United States of America (USA) among 1237 diabetic adults aged 20 years and older (Zhang *et al* 2008:1423). In addition, a low prevalence of visual impairment was reported in a study in the United Kingdom among 50331 people with DM aged ≥ 12 years old. In that study, the prevalence of visual impairment ($VA < 6/12$ to $\geq 6/60$) and severe visual impairment ($VA < 6/60$) was 3.4% and 0.4%, respectively (Sivaprasad *et al* 2012). In a study in Hong Kong among 2301 type 2

DM patients aged ≥ 23 years old, the prevalence of visual impairment was 11.3%, with 10.6% being mild ($VA < 6/18$ to $6/60$) and 0.7% being severe ($VA < 6/60$) visual impairment (Fung *et al* 2010). The reason for the higher prevalence of VI and blindness in this study compared to the above studies may be due to the differences in the definition of VI and blindness; populations studied, study sites and methods.

Firstly, the higher prevalence of VI in this study when compared to that of the above studies might be attributed to differences in the definition of VI. This is because participants, who are considered to be visually impaired in this study, are considered to be having normal vision when the definitions in the above three studies are used. For instance, participants with $VA \geq 6/12$ have normal vision in the above USA and UK studies. Those with $VA \geq 6/18$ are considered to be having normal vision in the Hong Kong study. The definitions used in the above three studies might have contributed to the lower prevalence in these studies compared to the present study.

Secondly, the fact that this study was done on older participants than those in the above three studies may be the other reason for the higher prevalence in this study than in those studies. Many of the causes of visual impairment including cataract, glaucoma, diabetic retinopathy, macular degeneration etc are age-related. A recent study has found that increasing age is a risk factor for visual impairment among persons with DM (Sivaprasad *et al* 2012).

Thirdly, the other reason for the higher prevalence, which was mostly due to refractive and cataract in this study may be that this study was done in a developing country, where there is a lack of eye care services when compared with the other studies that were done in developed countries, where spectacles and cataract surgery are widely available. The prevalence of VI has been found to vary from country to country and approximately 87% of people with visual impairment reside in the developing countries (Resnikoff *et al* 2004:848, WHO 2010). It is estimated that the number of eye care

providers per million populations in the richest countries may be nine times more than in the poorest countries (Ntsoane & Oduntan 2010:184). In many developing countries, eye specialists are concentrated in major cities and towns, and thus excluding, for instance, the majority of rural people requiring cataract surgery (Vaidyanathan, Limburg, Foster & Pandey 1999:104).

As in other developing countries, most practising optometrists and ophthalmologist in South Africa are either in private practice or in the urban areas. These practitioners only serve a small fraction of the population that can afford private health care services, with the majority dependent on the public sector for eye care services. (Naidoo 2007:418). There are about 70 ophthalmologists, 5 ophthalmic medical officers, 74 optometrists and 65 ophthalmic nurses in the public sector serving about 38 million people who are dependent on the public sector for eye care (Leucona & Cook 2011:510). Of the 4,718,043 million people dependent of the public sector for eye care in the Limpopo Province, where this study was done, only 4432 people had cataract operation in 2006 (Leucona & Cook 2011:510). Cook & Stulting (1995) estimated that in the rural areas of South Africa, there was an incidence of 27,000 blinding cataracts per year and a backlog of 113000 un-operated cataract-blind people. The study site for this study has undoubtedly contributed to the high prevalence of VI and blindness.

Fourthly, the higher prevalence in this study compared to the studies in the US, UK, and Hong Kong may be because this study was health facility-based compared to the above three studies, which were population-based. Clinic-based studies have been found to overestimate the frequency and severity of diseases (Williams *et al* 2004:975). This may be because people who visit the clinic or hospital for check-up may already be visually impaired, which may not be the case with those selected randomly from the community.

The high prevalence of VI in this study may also be due to lack of knowledge about the availability and accessibility of eye care services. It was discovered during the interviews that many of the participants were unaware that there were optometrists in the hospitals in the Mopani District. Some were not even aware that wearing glasses or having cataract operation might improve or restore their vision, as they considered their VI as an inherited condition. If people are unaware of the availability of eye care services in the hospitals suggests that they are unlikely to visit those facilities when they have eye problems. According to Sacharowitz (2005:146) factors such as cost, accessibility of service, poor knowledge of availability of services, fear of the outcome of surgery and cultural beliefs are some of the barriers that prevent people from presenting for eye consultation and management of their eye problems. Ntsoane & Oduntan (2010:183) also identified lack of awareness that the causes of visual impairment are preventable, non-availability of accessible and affordable services as the main causes of visual impairment and blindness.

Further, the fact that most participants were poor and relied on government pensions for survival implies that even if they were aware of the availability and accessibility of the services, they might not be able to afford eye care services, including spectacles. Naidoo (2007: 418) indicated that lack of affordable services and the absence of appropriate resources to purchase spectacles have the potential to confine many to poverty and drive others into poverty by restricting them from participating in economic activity.

6.6.2 Prevalence of visual impairment and blindness among the participants after optical correction

Contrary to the presentation of visual impairment and blindness among the participants based on presenting visual acuity, several authors have presented their findings based on corrected visual

acuity. It was therefore decided to present the findings in this study based on corrected visual acuity as well, so that result could be compared with those of other studies where possible. As mentioned above, results in this type of presentation should be treated with caution. For instance, the optical correction in this study was determined from auto refraction and pinhole test results and not from subjective refraction as is the case with other studies. These differences in methodology may influence results.

Using this type of presentation, Saaddine *et al* (1999:1201) investigated the prevalence of VI among 85447 adult people with DM 18 years and older in the USA and found overall prevalence to be 24.8%. This value is lower than the 41.3% found in the present study. Possible reasons for the differences may be due to the following: firstly, this USA study included some participants that were younger than those in the present study were. Secondly, this study was done in a developed country, which has better resources than in the developing country where the present study was done. Thirdly, the prevalence of visual impairment in the USA study was self-reported and this might have lead to underestimation of the prevalence of visual impairment. A lower prevalence of visual impairment (11%) was also reported in another USA study, in the New Jersey among 725 African Americans with type 1 DM aged 3 to 80 years (Roy 2000:102). The reasons for the differences are similar those discussed in the above USA study. In another population-based study in the USA (American Medical Association 2011) among people with DM aged 18 years and older, the prevalence was also found to be lower (18.6%) than that in the present study. Differences may be attributed to the same reasons as discussed above.

The findings of some of the studies in Europe also reported lower prevalence than what was found in this study. In a study in Denmark to determine the prevalence of diabetic retinopathy and causes of visual impairment ($VA < 6/20$) among 378 type 2 DM patients, the prevalence was 4% (Hove *et al* 2004:446). Another population-based

study in Denmark to investigate a broad range of predictors of vision loss among 1241 newly diagnosed type 2 patients (de Fine *et al* 2011) also reported lower prevalence of VI (5.4%) and blindness (0.9%). Lower prevalence (10.2%) was also reported in a study in Laxå community, Örebro County, in Sweden among 276 type 2 diabetes patients aged 24 to 91 years to establish a gold standard for prevention of blindness (Olafsdottir *et al* 2007:43). The lower prevalence in these European studies compared to the present study may be attributed to the differences in the definition of VI, age, populations studied, and methodologies.

In addition, lower values of prevalence of VI had been reported in the Middle East. In a cross-sectional study in Iran to investigate the risk factors of low vision among 738 type 2 diabetic patients (Horri *et al* 2011), a prevalence (VA<6/12) of 13.3% was reported. In another population-based study in Tehran Province, Iran (Javadi *et al* 2009) among 634 people with diabetes aged 25 to 64 years old, the reported prevalence of VI (VA<6/18) was 6.5%. In a population-based study in Pakistan to estimate the prevalence of DR among newly diagnosed people with diabetes, the prevalence of VI was 39.6% (Shaikh *et al* 2008:777). Differences may be attributed to differences in the definition of VI, methodologies, study sites and populations studied.

A higher prevalence (55.4%) was reported in a hospital-based study among 350 patients in Yemen to estimate the magnitude and risk factors of diabetic retinopathy. The probable explanation for this might be that over half (52%) of the patients in the Yemen study had DM for >10 years, compared with under a third (29.3%) of patients with similar duration in this study. Another explanation might be that in the Yemen study, the prevalence of DR was 55%, compared with 7.1% found in this study.

A low prevalence of 4% was also reported in a cross-sectional study among 1414 type 2 patients in Chennai metropolis, India (Rani *et al*

2012). Differences in the population, study sites and methodologies may be responsible for the differences in the prevalence. In a study in Southwestern Nigeria among 83 type 2 DM patients aged ≥ 16 years old, the prevalence of VI (VA $<6/18$) was lower (3.6%) than what was reported in the present study (Onakpoya *et al* 2010:177). A lower prevalence (12.3%) of VI (VA $<6/18$) was also reported in a study in Hlabisa District in the Kwazulu Natal Province, South Africa (Rotchford & Rotchford 2002:538) among 253 people with DM aged 21 to 81 years. The differences in the definition of VI and age of the participants may be the reasons for the low prevalence in the South African study.

The prevalence of blindness (3.6%) reported in this study is higher than that reported in other studies. The prevalence reported from the study in the US was 0.3% (Ryskulova *et al* 2008). The prevalence reported from the study in New Jersey was 3.1% (Roy 2000:102). The prevalence in a study in Denmark among type 1 and type 2 patients was 0.6% and 1.5%, respectively (Jeppesen & Bek 2004:528) and in another study in Denmark among type 2 patients, the prevalence was 0.9% (de Fine Olivarius *et al* 2011). In a study in Helsingborg city, Sweden, the prevalence of VI was 0.4% (Henricsson *et al* 1996:535), whilst in a study in Örebro County, Sweden, the prevalence was 2.9% (Olafsdottir *et al* 2007:43). In a study in Tehran, the prevalence was 1.6% (Javadi *et al* 2009). In a study (Bucher & Ijsselmuiden 1988:723) to determine the prevalence and causes of blindness in the Elim hospital District of Gazankulu in the Northern Transvaal (now Limpopo Province), South Africa among 18962 people of all ages, the prevalence was lower (0.57%) than in the present study. The low prevalence in the above studies may be attributed to various factors, including differences in the definition of VI and blindness, and research methodology in general.

Some studies in the Middle East reported higher prevalence of blindness than that reported in the present study. In a population-based study in Yemen (Bamashmus *et al* 2009:294), the prevalence

was 21%. As stated above, the probable explanation for this might be that over half (52%) of the patients in the Yemen study had DM for >10 years, compared with under a third (29.3%) of patients with similar duration in this study. Another explanation might be that in the Yemen study, the prevalence of DR was 55%, compared with 7.1% found in this study. In a study in Iran (Horri *et al* 2011), the prevalence was 5.5%. The reason for this might be that 30.5% of the patients in the Iranian study had >15 years duration of DM, compared with 14.9% in the present study with similar duration.

A higher prevalence (12%) of blindness (VA<3/60) than what was reported in this study was reported in a study in Southwestern Nigeria. The author cited symptom-dependent eye care services use as against screening as one of the reasons for the high rate of visual impairment and vision threatening diseases (Onakpoya *et al* 2010:178).

6.6.2.1 The prevalence of visual impairment and blindness according to age

Findings of this study seem to be consistent with previous research, which found the prevalence of VI and blindness to increase with increasing age. In a population-based study in Southern Wisconsin, USA, the prevalence of visual impairment and blindness among diabetic patients was found to increase with increasing age (Klein & Klein 1995:296). In another study in the USA, the overall prevalence of self-reported VI increased from 5.7% to 21% in those between 18-44 years and those above the age of 75 years, respectively (Ryskulova *et al* 2008). The prevalence increased significantly with age, from 18.6% among persons aged 18 to 44 years to 24.7% in another USA study among persons aged 45 to 64 years (Saaddine *et al* 1999). In the New Jersey study, the prevalence of VI increased from 7.6% in those younger than 18 years to 32.8% in those who were 45 years and older (Roy 2000:102).

The statistically significant association between VI and blindness (after optical correction) and increasing age ($p=0.02$) in this study support findings from other authors. In a study in the United States, the prevalence of self-reported visual impairment was found to be significantly associated with age ($p<0.04$) (Saaddine *et al* 1999). In the New Jersey study, older age was found to be inversely associated with higher frequency of visual impairment (OR=1.06; 95%CI, 1.01-1.13) (Roy 2000:102). In a study in Sweden, increasing age was found to be significantly related to worsening of BCVA in diabetic patients ($p<0.0001$) (Olafsdottir *et al* 2007:46). Increasing age was found to be significantly associated with VI and blindness, in a study in Iran (Horri *et al* 2011). In a study in Chennai metropolis, India, to report the prevalence of visual impairment and the associated risk factors in 1414 type 2 diabetic patients aged > 40 years, advancing age was found to be an important risk factor for VI. People with DM aged >60 years were seven times more likely to develop visual impairment than those \leq 60 years (Rani *et al* 2012:132).

In a study in Kinshasa, Congo to determine whether diabetic retinopathy is independently related to visual disability in Black diabetic patients aged 21 to 88 years, older age was found to be significantly associated with visual disability. Participants who were ≥ 60 years were almost twice at risk of visual disability than those who were <60 years (OR =1.7; 95%CI 1-2.9; $p=0.020$) (Mvitu Muaka & Longo-Mbenza 2012:194). In a population-based study to estimate the prevalence and causes of visual impairment and blindness in Cape Town, South Africa, the prevalence of visual impairment among the general population aged ≥ 50 years was found to increase significantly with increasing age ($p<0.001$) (Cockburn, Steven, Lecuona, Joubert, Rogers, Cook & Polack 2012).

6.6.2.2 The prevalence of visual impairment and blindness according to gender

In this study, the prevalence of VI and blindness was 50% among the males and 45.6% among the females and there was no significant association between VI and blindness and gender ($p=0.385$). This finding support previous research which found no significant association between VI and gender. Some studies (Henricsson *et al* 1996:535, Horri *et al* 2011) found that female gender was not significantly associated with visual impairment. However, several studies have reported that females were at higher risk of visual impairment and blindness than males. In a study in the New Jersey, female gender was found to be independently associated with higher frequency of VI (OR=2.38; 95%CI, 1.03-5.54) (Roy 2000: 102). In another study in the USA, female gender was significantly found to be associated with VI ($p<0.02$) (Saaddine *et al* 1999:1201). In a study in Örebro County, Sweden, female gender was found to be associated with worsening of BCVA among diabetic patients (Olafsdottir *et al* 2007:45). In a study in Kinshasa, Congo female gender (OR=1.7; 95%CI 1.02-2.7; $p=0.028$) conferred a double risk of visual disability compared to the male gender (OR=1.7; 95%CI 0.87-2.5; $p=0.099$) (Mvitu Muaka & Longo-Mbenza 2012:194).

The fact that there were more males than females with VI and blindness in this study disagrees with the reports by authors who found that there were more females than males with VI and blindness. The prevalence of visual impairment in a US study was found to be significantly higher among females than among males and the risk of having VI and blindness was found to be 2.7 times for women compared with men (Ryskulova *et al* 2008). The frequency of VI was found to be significantly higher in females (13.3%) compared with males (7.7%) (Roy 2000: 102). In a study in the Northern Transvaal, South Africa, women were found to be significantly more affected by blindness than men were ($p<0.0001$). Low literacy rate in

women was cited as the reason for the higher proportion of untreated senile cataract in women (Bucher & Ijsselmuiden 1988:723). There is no obvious explanation for the higher percentage of VI and blindness among male than among female in this study.

6.6.2.3 The prevalence of VI and blindness according to educational qualification

Findings in this study revealed that the prevalence of VI and blindness was lower among participants with tertiary education (2.7%) compared to those with primary education (19.3%) (See Table 5.10). Although there was a significant association between VI and blindness and educational qualification before optical correction ($p=0.021$), it was not the case after optical correction ($p=0.156$).

The fact that the prevalence of VI and blindness was lower among those with tertiary education than among those with primary education is in agreement with what was reported by other authors that the prevalence of visual impairment tend to decrease with increasing level of education. In a study in the US, visual impairment was found to be significantly associated with educational level among insulin users ($p<0.05$). Almost half of all insulin users and more a third of non-insulin users who had not completed high school reported having VI compared to fewer than a fifth of those who had higher level of education (Saaddine *et al* 1999:1203). No reason was given for the differences, but it may be that people with low level of education are more likely to be unemployed or poor compared to those with high education level and therefore may not afford eye care services.

In a study conducted in the United States, people with less education, especially those with less than high school education were more likely to have uncorrectable VI than those with above high school education (Zhang *et al* 2008:1423). In another study in

the US, people with low education were found to be twice as likely to be visually impaired than those with higher education (Ryskulova *et al* 2008).

In a study in the New Jersey, higher education level was weakly associated with lower risk of VI (OR=0.44, 95%CI, 0.18-1.07) (Roy 2000:102). In a study in Tehran to determine eye care utilization among 4565 persons aged 1-96 years, higher levels of education was associated with higher likelihood of seeking eye care. This relationship was attributed to greater knowledge and therefore more reasonable health-seeking behaviour. In addition, educated people were presumed to be members of the higher socioeconomic class and may thus have better access to eye care services and find them affordable (Fotouhi, Hashemi & Mohammad 2006).

Low educational attainment was found to be associated with visual disability ($p=0.000$) in a study among diabetic patients in Kinshasa, Congo (Mvitu Muaka & Longo-Mbenza 2012:194). Lack of formal education has been found to be a significant predictor of vision loss in a study in Cape Town, South Africa (Cockburn *et al* 2012).

The reason for the lower prevalence of visual impairment among participants with tertiary education compared to those with primary education may be that the former are likely to be better informed than the latter about the risk factors for visual impairment and blindness and could therefore seek medical intervention before they are visually impaired or blind. In addition, persons with tertiary education are likely to be receiving higher income than those with primary education and could therefore afford spectacles and cataract surgery.

6.6.2.4 Prevalence of visual impairment and blindness according to monthly income

In this study, monthly income was significantly associated with VI and blindness ($p=0.030$), and the risk of those with no income being visually impaired was 2.56 times that of those with high income. This agrees with reports from a study in the USA, which found that people with low income were twice as likely to be visually impaired than those with higher income (Ryskulova *et al* 2008). In another study in the USA among people with DM aged ≥ 18 year, employment status was found to be significantly associated with visual impairment; the retired and unemployed were more likely to have VI (chi-square=8.7, $p<0.01$) (Saaddine *et al* 1999:1202). In a study in India among people with DM aged > 40 years, low socioeconomic status was found to be significantly associated with increased risk of VI (Rani *et al* 2012:131). However, other studies did not find any association between visual impairment and family income (Roy 2000:102).

That the prevalence of VI and blindness was high among participants with monthly income of $\leq R2000$ (Table 5.9) may be explained by the fact that many of the participants were receiving government old-age pension, which is about R1200. The other reason may be due to the lack of access to cataract surgery and affordable spectacles in the public sector in the Limpopo Province. To the researcher's knowledge cataract surgery in the Limpopo Province is only done at Elim and Mankweng Hospitals, which are about 150km from where the study was conducted.

6.6.2.5 Prevalence of visual impairment and blindness according to marital status

In this study, the prevalence of VI and blindness was 41.1% among the married participants and 61.2% among the widowed (See Figure 5.17). That there was no significant association between visual

impairment and blindness and marital status ($p=0.285$), is in agreement with the findings from another study (Roy 2000:102), which found no significant association between VI and marital status ($p=0.34$).

6.6.2.6 Prevalence of visual impairment and blindness according to the place of residence

The prevalence of visual impairment and blindness among rural dwellers was 43.9% and no VI and blindness was found urban dwellers (Figure 5.18). The fact that there was higher percentage for those living in the rural areas compared with those in other places of residence in this study may be because the majority of the participants in this study were from the rural areas (68.9%). Another possible explanation for the high prevalence of VI and blindness among participants in the rural areas may be that there is the lack or shortage of eye care services in these areas when compared with the urban and semi-urban areas. In South Africa, there is a disparity in access to and provision of eye care services across the provinces. In general, services provided in the urban areas are always better than those available in the rural areas where access to even the most basic eye care and vision rehabilitation services is often non-existent (Sacharowitz 2005:146). Oduntan & Raliavhegwa (2001) cited by Sacharowitz (2005:146) reported that factors such as poor economic status, lack of transportation, level of literacy, lack of awareness and traditional beliefs among people in the rural areas are responsible for underutilisation of eye care services, where they exist. Their study also reported that eye care services in disadvantaged communities should not be limited to the provision of eye and vision needs, but should include education and eye health promotion as preventive measures (Oduntan & Raliavhegwa 2001).

6.6.2.7 Prevalence of visual impairment and blindness according to the ethnic group

Several studies have reported that the prevalence of visual impairment varies among the different racial/ethnic groups. In a study in the USA, people with DM from other racial/ethnic groups were found to have twice the risk of visual impairment as that of non-Hispanic Whites. The reason for the racial/ethnic group difference is that people in the minority groups are less likely than whites are to seek medical care (Saaddine *et al* 1999:1203). In the study in the UK to estimate the prevalence of VI among 50331 multi-ethnic people with DM of all ages, minority ethnic groups (South Asians and Blacks) were twice as likely to be visually impaired compared to their White counterparts (Sivaprasad *et al* 2012). In the present study there were differences in the prevalence of VI and blindness for the different ethnic groups, however, there was no significant association between visual impairment and ethnic group ($p=0.2196$). The Sotho- and the Shangaan- speaking participants were found to have higher percentages of VI and blindness when compared to those who spoke Venda or other languages (Figure 5.19). The reason for this finding is that there were more Sotho - and Shangaan - speaking participants than the other ethnic groups in this study (Figure 5.3).

6.6.2.8 Prevalence of visual impairment and blindness according to the body mass index

Several population-based studies have correlated increased BMI as a risk factor for diabetic retinopathy, which is the leading cause of vision loss and blindness worldwide. The evidence supporting the relationship between high BMI and increased risk of DR is inconclusive (Dirani, Xie, Fenwick, Benarous, Rees, Wong, Lamoureux 2011:4416). For instance, in a study in Melbourne, Australia to investigate the relationship between anthropometric

parameters and diabetic retinopathy (DR) in people with DM aged between 26 and 90 years, BMI and neck circumference were significantly associated with having any DR. The obese (BMI $>30\text{kg/m}^2$) were more than 3 times likely to have any DR (OR, 3.12; 95%CI, 1.20-8.16; $p=0.02$) and 6.5 times as likely to have PDR (OR, 6.52; 95%CI, 1.49-28.6; $p=0.0013$) compared with those with normal BMI. In women, BMI and waist circumference were significantly associated with any DR (Dirani *et al* 2011:4417).

In a study in Iran, higher BMI was also found to be associated with VI and blindness (Horri *et al* 2011). Weight loss has been suggested to delay the onset of diabetic complications and this provides some evidence to support the relationship between higher BMI and DR. However, there has also been a report that suggests that weight loss increases the risk of developing early DR among type 1 patients (Dirani *et al* 2011:4420).

In contrast, some studies found low BMI to be associated with VI and blindness. In a study in Örebro County, Sweden, a lower BMI of 1kg/m^2 increased the risk of being blind by 34% among people with DM aged 15 years and older. A lower BMI in this population was seen as a sign of being in the catabolic state and perhaps representing a premonition for death (Olafsdottir *et al* 2007:44). In a study in India, to report the prevalence of the different types of obesity and their association with diabetic retinopathy among 1414 subjects aged ≥ 40 years, the prevalence of diabetic retinopathy (DR) and sight-threatening diabetic retinopathy was more in the isolated abdominal obesity [Waist circumference (WC) $\geq 90\text{cm}$ for men & $\geq 80\text{cm}$ for women, normal BMI $<23\text{kg/m}^2$] group than in the other sub-groups. Increased BMI and combined obesity were noted to have a protective role for any DR in both genders. The probable reason for the protective effect of increased BMI on DR is the observation that DM patients with high BMI use less insulin injections, which suggests better beta cell reserve (Raman *et al* 2008).

In this study there was no association between visual impairment and BMI, although visual impairment and blindness was more common among participants who were obese (BMI $\geq 30\text{kg/m}^2$) than among those who were not (Figure 5.20). The reason for the higher prevalence of visual impairment among the obese may be that most of the participants in this study were obese (See Figure 5.14). These findings are in agreement with findings reported in other studies (Roy *et al* 2007, Rani *et al* 2012) who did not find any significant association between VI and blindness and BMI.

6.7 THE CAUSES OF VISUAL IMPAIRMENT AND BLINDNESS AMONG THE PARTICIPANTS

This study showed that the leading causes of reduced presenting visual acuity (visual impairment) were refractive error (49.5%) and cataract (24.7%). Visual impairment due to these conditions can be reversed by using of spectacles and cataract surgery. This implies that about 50% of the participants are needlessly visually impaired. However, following optical correction the leading causes of VI and blindness were cataract (76.8%) and diabetic retinopathy (7.1%) (See Tables 5.15 & 5.18). The fact that refractive error was the leading cause of presenting VI supports the reports by other authors that uncorrected refractive error is the leading cause of visual impairment. The WHO reported that uncorrected refractive error was the leading cause of VI globally (WHO 2012).

According to Sacharowitz (2005:143) uncorrected refractive errors are a significant cause of avoidable visual disability, especially in developing countries. Uncorrected refractive errors were also found to be the leading cause of VI in a study in Tehran, Iran among the general population of all ages to determine the prevalence and causes of VI before optical correction (Fotouhi, Hashemi, Mohammad & Jalali 2004:744). In a population-based study in Cape Town, South Africa among 2750 people aged ≥ 50 years to estimate the

prevalence and causes of visual impairment and blindness, uncorrected refractive error was also found to be the leading cause of VI (50%) (Cockburn *et al* 2012).

Lack of eye care practitioners especially optometrists in the public sector may be one of the reasons for the high prevalence of VI due to refractive error in this study. As stated above, there are only 74 optometrists in the public sector serving about 38 million people dependent of the public sector for eye care (Leucona & Cook 2011:510). Although currently there are optometrists employed in the public sector in the Limpopo Province, most of the participants were unaware of the availability of the services. This suggests that the optometry services remain inaccessible to most people. As stated above, Oduntan & Raliavhegwa (2001) cited by Sacharowitz (2005:146) reported that eye care services in disadvantaged communities should not be limited to the provision of eye and vision needs, but should include education and eye health promotion as preventive measures. Eye health promotion would improve accessibility to eye care services. Affordability is also one of the most important barriers in accessing eye care services. This suggests that even if services are available, people who cannot afford spectacles will remain with visual impairment.

The results from this study showed that after optical correction, cataract was the most common cause of VI and blindness, followed by diabetic retinopathy (Table 5.18). This finding corroborates previous reports that found cataract to be the leading cause of VI and blindness in many countries. In the WESDR study in the USA, cataract was the leading cause of blindness among type 2 patients (Klein *et al* 1995:296). In another USA study to estimate the prevalence of self-reported VI, blindness, and selected eye conditions in the general population, cataract (19.4%) was also a leading cause of visual impairment (Ryskulova *et al* 2008).

In a study in Örebro County, Sweden, cataract (19%) was the leading cause of visual impairment (Olafsdottir *et al* 2007:43). In a study in Denmark to examine a broad range of predictors of vision loss among 1241 type 2 DM patients aged ≥ 40 years, cataract was found to be the most common cause of visual impairment (de Fine Olivarius *et al* 2011).

In a study in Yemen to assess the causes of visual impairment and blindness among 694 diabetes patients, cataract (30%) was the leading cause of VI and blindness (Al-Akily *et al* 2011:834). Cataract was also found to be the leading cause of VI in a study in Tehran, Iran among the general population of all ages to determine the prevalence and causes of VI after optical correction (Fotouhi *et al* 2004:744).

In a study among 840 West African type 2 DM patients to quantify the prevalence of, and risk factors for, diabetic retinopathy and cataracts, cataracts (44.9%) were a more important cause of visual impairment than diabetes retinopathy (17.7%) (Rotimi *et al* 2003: S2-113). The high prevalence of cataracts among the population was found to be due to DM. However, the high prevalence of cataracts among the control group suggests that there are other cataractogenic factors, unrelated to type 2 DM that play an important role in the development of cataract (Rotimi *et al* 2003: S2-113). In another African study, in Southwestern Nigeria among type 2 DM patients (Onakpoya *et al* 2010:177), cataract and glaucoma were the leading causes of visual impairment and blindness.

The possible explanation for cataract being the leading cause of VI and blindness in this study may be that cataract is generally an age-related condition and many of the participants were 60 years and older (See Table 5.2). Another possible explanation may be the fact that persons with DM are at higher risk of developing cataract compared to those without DM (IDF 2006:114).

In some previous studies, diabetic retinopathy was found to be major cause of visual impairment and blindness. In the WESDR study, diabetic retinopathy was the leading cause of blindness among type 1 patients and cataract was the leading cause among type 2 patients (Klein *et al* 1995:296). In the New Jersey study, diabetic retinopathy was the leading cause of VI (62%) and legal blindness (90.9%) among 725 type 1 patients aged 3 to 80 years (Roy 2000:102).

In a study in Denmark, proliferative diabetic retinopathy (66.2%) was leading cause of blindness among type 1 patients of all ages (Jeppensen *et al* 2004:528). In a study in Århus County, Denmark, diabetic retinopathy was the number one cause of visual impairment, followed by cataract and ARMD in third place (Hove *et al* 2004:446). Diabetic retinopathy (DR) was found to be the leading cause of visual impairment and blindness among 1769 persons with DM <75 years old in Helsingborg city, Sweden (Henricsson *et al* 1996:533).

In a study in Luganville, Vanuatu to determine the prevalence and severity of diabetic retinopathy among 68 type 2 DM patients, diabetic retinopathy was the leading cause of visual impairment and blindness followed by cataract (Smith, Szetu & Bourne 2007:417). The reason given for the high prevalence and severity of diabetic retinopathy in this Vanuatu study was the prevalence of well-established risk factors for DR progression, which include hypertension and poor glycaemic control in the population, suggesting that lifestyle interventions have not been optimised.

In some European studies, DR was found to be the second most common cause of visual impairment and blindness. In the study to determine the prevalence of significant VI related to DM and other causes in the working age population in the Newcastle District, England, diabetic retinopathy was found to be the second commonest cause of visual impairment and blindness, after stroke and optic atrophy, respectively (Arun *et al* 2009: 489). In another study in Denmark among 1241 newly- diagnosed type 2 patients

aged 40years and older, DR was the second common cause (de Fine Olivarius *et al* 2011). This agrees with the finding in this study that diabetic retinopathy is the second common cause of VI and blindness.

6.7.1 Causes of visual impairment and blindness in the right and left eyes of the participants

There was no difference between the leading causes (refractive error and cataract) of presenting visual impairment and blindness the right and left eyes of the participants. Following optical correction, the leading causes in the right and left eyes were cataract and diabetic retinopathy (Figures 5.21 & 5.24).

6.7.2 Causes of visual impairment and blindness in the right and left eyes according to gender

It is unclear why VI and blindness (before optical correction) due to refractive error was more common in the right eyes of males than in those of females, and that VI and blindness due to cataract was more common in females than in males (Figures 5.22 & 5.23). The higher proportion of females than males in the 60 years and older age range (Figure 5.1) may explain the higher prevalence of VI and blindness (after optical correction) due to cataract in females than in males. The reason for this is that age is an important risk factor for the development of cataract (Robman & Taylor 2005:1074). No reason could be given why the prevalence of visual impairment and blindness due to cataract was similar in the right eyes of both males and females, and cataract was the major cause in the left eyes of females than those of males (Figures 5.25 & 5.26).

6.7.3 Causes of visual impairment and blindness in the right and left eyes according to age

It was expected that cataract was the leading cause of VI and blindness among participants aged 60 years and older, since it is an age-related condition. This agrees with what was reported in another South African study that the prevalence of blindness rose sharply after the age of 60 years in both sexes (Bucher & Ijsselmuiden 1988:723). Blinding trachoma and untreated senile cataract especially among women was the reason for the high prevalence of blindness in those above the age of 60 years. The excess risk of blindness among the women was attributed to low literacy rate and slightly higher average age (Bucher & Ijsselmuiden 1988:723). In addition, persons with DM are at higher risk of cataract when compared to those without this condition.

The fact that DR was not found in participants below the age of 55 years in this study agrees with previous reports that the prevalence of DR significantly increases with age. In a cross-sectional study conducted in patients with newly diagnosed type 2 DM in Tehran, Iran diabetic retinopathy was significantly associated with increase in age (Abdollahi *et al* 2006:416). Also, in a study conducted on 513 diabetic patients of all ages in Al-Ain city, United Arab Emirates, diabetic retinopathy was significantly associated with increasing age ($p<0.01$) (Al-Maskari *et al* 2007). Further, in a study to assess the prevalence, potential risk factors for diabetic retinopathy in the Indian state of Andhra Pradesh, increasing age, socioeconomic status, and duration of DM were significantly associated with increasing risk of DR (Krishnaiah *et al* 2007:478).

6.8 CLINICAL RISK FACTORS FOR VISUAL IMPAIRMENT AND BLINDNESS AMONG DIABETIC COHORT

6.8.1 Duration of diabetes mellitus

The results from this study showed that the proportion of participants who had been diabetic for >20 years was less than 5%. About forty percent (39.6%) had been diabetic for < 5 years (Table 5.22). The small proportion of those who had been diabetic for > 20 years compared to those who had been diabetic for <5 years is in agreement with what was reported in another South African study. In a study in Durban, South Africa to evaluate the level of knowledge of DM, its complications and management among 106 people with DM aged 30 to 85 years, only 1% of the participants had been diabetic for >20 years. More than half (55%) of them had been diabetic for ≤5 years (Mashige *et al* 2008:98).

The low proportion of those who have had DM for >20 years may be attributed to the fact that DM was not very prevalent among South Africans in the past. As stated in Chapter 2, the number of South Africans with DM was estimated at 298000 in 1995 (King *et al* 1998: 1430). However in 2011, the number was estimated at 1.9 million, with at least 78% of the people with DM being undiagnosed (International Diabetic Federation 2011). In the past, DM was more prevalent among South Africans residing in the affluent urban areas. Now, due to westernisation of the rural communities, (which includes physical inactivity and replacement of traditional nutritious diets with western-style diets), it is increasingly becoming more prevalent among the rural South Africans (Moodley & Rambiritch 2007).

6.8.1.1 The prevalence of visual impairment and blindness according to duration of diabetes mellitus

Several studies have found high prevalence of visual impairment to be associated with duration of DM. It was also expected that this

would be the case in this study, however, that was not the case. In a WESDR study, in the USA, the prevalence of blindness among type 1 patients increased from 3% in those with 15-19 years duration to 12 % in persons with DM for ≥ 30 years. Among type 2 patients, the prevalence of legal blindness was relatively lower, and reached only 7% in patients having DM for 20-24 years (Klein & Klein 1995:296). In another study in the USA, the prevalence of VI among insulin and non-insulin users were higher among participants with ≥ 10 years duration, compared to those with < 10 years duration of DM (Saaddine *et al* 1999:1201). In a study in the New Jersey (Roy 2000:102), the prevalence of VI was found to be strongly and positively associated with duration of DM (OR=1.08, 95%CI, 1.05-1.10). The finding was reported in a study in southern Sweden, where visual impairment and blindness was found to be significantly associated with long duration of DM (Henricsson *et al* 1999:535). In a study in Iran, visual acuity was observed to significantly decrease with increasing duration of DM ($p < 0.0001$) (Horri *et al* 2011).

In a clinic-based study in Kinshasa, Congo among 229 black persons with DM aged 21-88 years to determine whether diabetic retinopathy is independently related to visual disability, duration of DM was not associated with visual disability ($p = 0.336$) (Mvitu & Longo-Mbenza 2012:195). This is in agreement with what was found in this study where duration of DM was not associated with VI and blindness ($df=3$, $\chi^2 = 1.8$, $p = 0.614$).

The prevalence of VI and blindness was 16.4% among participants with < 5 years duration of DM and 2.7% among those with > 20 years duration (See Fig 5.27). This may be explained by the fact that a larger percentage (39.6%) of the participants had DM for < 5 years, and less than 5% of them had the condition for > 20 years. The fact that more than half (54.7%) of the participants were 60 years and older, which suggests that when they were diagnosed with DM they may have been visually impaired due to other age-related causes.

For instance, the leading cause of VI and blindness in this study was cataract, which is normally associated with increasing age.

6.8.2 Knowledge of diabetes mellitus types

The results from this study showed that many (68.3%) of the participants did know the types of DM and only about twenty percent (19%) reported knowing two types of DM (Table 5.23). This is a concern since the knowledge and practices that diabetic patients have about the disease have an effect on the compliance and the successful management of the disease (Phillips *et al* 2012:74). Studies to evaluate the level of knowledge about DM among diabetic patients have been done in some areas of South Africa. In a study in Cape Town, South Africa (Clarke-Farr *et al* 2008:137) among 98 people with DM aged 20-89 years, the percentage of participants who either did not know the type they had or did not answer the question on the knowledge of DM types was lower (15%) than that reported in this study. In addition, the percentage of those who reported knowing the existence of two types of DM was higher (42%) than that reported in this study. The difference in the knowledge about DM in the two studies may be due to the historical inequalities of the past with regard to proper education, health services and health education.

As mentioned above, Blacks were deliberately undereducated through the system of Bantu education, which implies that the other race groups had better education than the Blacks did. The Cape Town study comprised of 90% Coloured and only 7% Black participants, whereas this study comprised 100% Black rural participants. It is therefore expected that the Coloured people, who stay in a Province where there is better education and resources would be better informed about the types of DM than the Blacks in this study did.

In another study in Cape Town, South Africa (Phillips *et al* 2012:72) among 73 privately-funded diabetic patients aged 33-80 years, the percentage (15%) of participants who did not know the types of DM was similar to that reported in the study by Clarke-Farr *et al* (2008:137), but was lower than the 68.3% reported in this study. The percentage of those who reported knowing two types of DM was higher (56%) than the 42% and 19% reported in above study and in this study, respectively.

In a study in Durban, South Africa to assess the level of knowledge of diabetes mellitus, its complications and management among 106 diabetic patients aged 30-89 years, the majority (96%) of them reported that they knew two types of DM and 4% were unsure (Mashige *et al* 2008:98). This value (96%) is higher than the 42%, 56%, and 19% reported in the above two Cape Town studies and in this study, respectively. The differences may be attributed to the differences in populations studied, study sites, literacy levels among the participants in these studies. According to Mashige *et al* (2008:100), the increased knowledge about DM among the participants may be attributed to the easy access to advice in the medical facilities in Durban. The deficiency in the knowledge about DM types in the present study suggests that there is lack of advice about the types of DM in the public health facilities in the Mopani District, Limpopo Province.

6.8.2.1 The prevalence of visual impairment and blindness according to the knowledge of diabetes types

Visual impairment and blindness was more common among participants who did not know any type of DM than among those who knew one type or more. The reason for this finding may be that there were more participants who reported that they did not know any type of DM, compared to those who reported knowing one type or more.

6.8.3 Type of diabetes mellitus

Most (90-95%) of the persons with DM have type 2 DM while a few (5%) have type 1 (Centers for Disease Control and Prevention 2011). It was therefore expected that the persons with type 2 DM (90.1%) would be more than those of type 1 DM (9.9%). Several studies also reported higher prevalence of type 2 DM in the different study populations. In a study in the UK, among 50331 people with DM of all ages, the prevalence of type 2 (93.4%) was higher than that of type 1 (6.7%) (Sivaprasad *et al* 2012). In a study in Tehran Province, Iran among 634 people with DM aged 25 and 64 years, the prevalence of type 2 (97.5%) was also higher than that of type 1 (2.3%) (Javadi *et al* 2009). In a study in Kinshasa, Congo, the prevalence was 67.6% and 32.4% for type 2 and type 1, respectively (Mvitu & Longo-Mbenza 2012:195). The number of type 2 patients was also found to be higher than that of type 1 in a study done in South Africa among 253 diabetic patients aged 21-81 years (Rotchford & Rotchford 2002:538).

6.8.3.1 The prevalence of visual impairment and blindness according to type of diabetes

The prevalence of visual impairment and blindness among participants with type 2 DM was 40.5% and among those with type 1 was 4.1%. The higher prevalence of VI and blindness among type 2 patients agrees with the findings from other studies. In a study in Århus County, Denmark, the point prevalence of legal blindness was higher (1.5%) among type 2 than among type 1 (0.6%) patients (Jeppesen & Bek 2004:528). These authors attributed the differences to the fact that diabetic retinopathy (DR) or visual loss may be present at the time of diagnosis of type 2 such that the available treatment modalities for DR may not fully prevent visual loss. In addition, the vast majority of visual loss in type DM is due to causes other than DR.

In a study in the USA among people with DM aged 18 years and older, the odds of having visual impairment among insulin users were 70% higher for persons with type 1 DM (OR, 1.7; 95% CI, 1-2.9; $p=0.02$) and 40% higher in those with type 2 (OR, 1.4; 95% CI, .1.03-1.9; $p=0.02$) compared to non-insulin users (Saaddine 1999:1202). In a study in the UK among people with DM of all ages, the risk of visual impairment in type 1 was found to be twice that in type 2 (Sivaprasad *et al* 2012). No explanation was given for the differences.

In a study in Kinshasa, Congo, the prevalence of VI was 61% and 39% for type 2 and type 1 DM, respectively (Mvitu Muaka & Longo-Mbenza 2012:195). No explanation was given for the differences, but the fact that there was a significant and positive association between visual disability and aging ($p=0.020$) and that the majority (92%) of the patients were ≥ 45 years, may be the reason for the differences.

The possible explanation for the higher prevalence for VI and blindness in this study may be due to the fact that there were more type 2 patients (90.1%) than type 1 patients (9.9%). In addition, type 2 patients are generally older than type 1 patients, which suggest that the age-related causes (cataract, glaucoma, diabetic retinopathy, etc) of visual impairment and blindness may be more prevalent among type 2 patients than among type 1 patients.

6.8.4 Diabetes mellitus treatment

As stated in Chapter 2, patients with type 1 DM require insulin injection for survival, whereas many of the type 2 patients use oral medication (pills or tablets) to control hyperglycaemia. However, some type 2 patients require insulin injection for metabolic control of hyperglycaemia rather than for survival (WHO 1999:14).

6.8.4.1 Use of insulin injection

The percentage of participants who used insulin injection in this study was 15.5%. This value is similar (15.3%) to the one reported in a study in Australia among 121 diabetic patients to describe the 5-year incidence and progression of DR in the Melbourne Visual Impairment Project (VIP) cohort (McCarty *et al* 2003:399). The proportion of insulin users in this study is higher than the 5.9% reported in a study in Luganville, Vanuatu among 83 diabetic patients to determine the prevalence and severity of DR, associated risk factors and vision loss (Smith *et al* 2006:416). The finding in this study is also higher than the 12% reported in a study in six sub-Saharan African countries among 2352 type 2 DM patients (Sobngwi *et al* 2012:32). However, the proportion of insulin users (15.5%) in this study is lower than the 31.7% reported in a study in Yemen among 350 people with DM (Bamashmus *et al* 2009:295). Differences in the populations studied may be responsible for this variation. The majority (93.1%) of the participants in the present study reported using their treatment as prescribed. This finding is similar to what was reported in another South African study (Rotchford & Rotchford 2002:538) where 94% reported having taken their medication in the past 3 days.

The use of insulin injection as a risk factor for visual impairment and blindness

The finding from this study that insulin injection was not significantly associated with VI and blindness agrees with findings previous authors. Henricsson *et al* (1996:536) in a study in southern Sweden reported that insulin treatment was not an independent risk factor for blindness or visual impairment in the multivariate analysis. No explanation was given. However, other studies found a significant association between visual impairment and insulin use. In a study in Los Angeles, California, among 1187 DM patients aged ≥ 40 years,

insulin use was associated with the presence any DR and PDR (Varma *et al* 2006: 1332). In a study in the USA, insulin treatment in both type 1 and type 2 was found to have increased odds of having visual impairment than non-insulin users (Saaddine *et al* 1999: 1202). No reason was given for this increased risk among insulin users. In a WESDR study in the USA among 1370 type 2 DM patients, insulin users had proportionately more severe retinopathy than non-insulin users. The reason for this may be that insulin users were younger at diagnosis, had been diabetic for a longer duration and had poorer glucose control than non-insulin users (Klein *et al* 1984:528). In addition, in a study in Chennai metropolis, India, visual impairment was found to be significantly associated with insulin use ($p=0.007$) (Rani *et al* 2012). No reason was provided for this significant association.

The low prevalence of VI and blindness among insulin users than among non-insulin users in this study (6.7% versus 38%), may be explained by the fact that the percentage of participants using insulin in this study was lower than that of non-insulin users (18% versus 89.7%). The other explanation may be that the major cause of VI and blindness after optical correction was cataract, which is more of an age-related condition than a diabetes-related one. The fact that the majority of the participants were older and had type 2 DM patients (mostly non-insulin users) may explain the higher prevalence of VI and blindness among non-insulin users.

6.8.4.2 Use of oral medication (Pills or tablets)

Type 2 DM was previously called Non-Insulin Dependent Diabetes Mellitus (NIDDM). This is because the majority of type 2 patients do not use insulin injection instead they use oral medication such as metformin tablets to control their condition (WHO 2009). Most (89.7%) of the participants in this study used pills to control their condition and all of them reported that they used their medication as prescribed. The percentage of participants using oral medication

was higher than what was reported in other studies. In a study in Luganville, Vanuatu among 83 type 2 DM patients, 69.1% of them used oral medication (Smith *et al* 2006:416). A lower percentage (29.6%) than was reported in the present study was also reported in a study in China to describe the risk factors associated with diabetic retinopathy among 368 type 2 diabetic patients aged ≥ 30 years (Wang *et al* 2011). In a study in Yemen (Bamashmus 2009:295) among 350 people with DM, the proportion of those using non-insulin treatment (68.3%) was lower than what was reported in this study.

A lower proportion (14.5%) of oral anti-diabetic medication users was also reported in a study Southwestern Nigeria (Onakpoya *et al* 2010:177) among type 2 diabetic patients aged ≥ 16 years old. The percentage of those using oral anti-diabetic medication (88%) was more or less similar to what was found in this study in a study in six sub-Saharan African countries (Sobngwi *et al* 2012:32),

a) The prevalence of visual impairment and blindness according to diabetes mellitus treatment (Pills/tablets)

The higher percentage of VI and blindness (41.3%) among those who used DM pills compared to those who did not (3.6%) in this study (Table 5.25) is in contrast to what was reported in other studies. The prevalence of VI among non-insulin users (22.7%) in the USA among 3388 adults with DM aged ≥ 18 years was lower than that among insulin users (28.3%) (Saaddine *et al* 1999:1202). The prevalence of any diabetic retinopathy (risk factor for VI) was lower among those who used oral medication (39.8%) than among those who used insulin injection (53.8%), in a study in Tehran Province, Iran among 634 people with DM aged 25 to 64 years (Javadi *et al* 2009).

The reason for the higher prevalence among those using pills in this study may be that most (89.7%) of the participants used pills for their diabetes (Table 5.25). The fact that the majority of the participants were older and had type 2 patients (mostly non-insulin

users) may explain the higher prevalence of VI and blindness among non-insulin users. As mentioned above, that the major cause of VI and blindness after optical correction was cataract, which is more of an age-related condition than a diabetes-related one.

However, the prevalence of VI and blindness in this study was not significantly associated with the use of DM pills ($p=0.306$). In contrast, the use of DM pills was found to be significantly associated with the presence of DR in a study in China among type 2 DM patients (Wang *et al* 2011).

6.8.5 Special diet, losing weight and physical activity as recommendations for diabetes control

Diabetic patients are often given other recommendations, such as special diet, physical activity, and losing weight as well as to stop smoking to help in the control of hyperglycaemia. Since all the participants in this study were using medical treatment (Insulin injection, oral medication or both), the above recommendations were used in combination with the medical treatment.

Participants in this study were asked whether special diet, reducing weight, and engaging in physical activity to control their disease has been recommended to them or not. Most (84.5%) of the participants reported that they have been advised to follow a special diet and 71.5% of them reported that they followed special diet as prescribed. Less than half (46.3%) of them reported having been advised to lose weight. Less than a third (29.1%) reported that they always try to lose weight (Table 5.26). Physical activity was recommended of 62.3% and nearly half (48.3%) reported that they always engaged in physical activity.

Several studies have shown that lifestyle changes (such as reducing weight, total fat intake and intake of saturated fats as well as

increasing intake of fibre and physical activity) in the high risk subjects may prevent or delay the incidence of type 2 DM.

In a study in the USA to determine if weight loss may prevent conversion of IGT to diabetes among 136 persons with IGT and clinically severe obesity (> 45 kg excess body weight), individuals with IGT who lost about 50% of excess body weight resulted in a significant reduction in the conversion rate of IGT to type II DM to a low of 0.15 cases per 100 person years. In contrast, those who did not lose weight developed type 2 DM at a rate of 4.72 cases per 100 person-years (Long, O'brien, Macdonald, Leggett-Frazier, Swanson, Pories & Caro 1994:374).

In a study in Finland among 552 subjects the incidence of type 2 diabetes was reduced by 58% in the intervention group (those advised on diet aimed at reducing weight) compared to the control group. This report provided more evidence that lifestyle changes may prevent the incidence of type 2 DM (Tuomilehto, Lindström, Eriksson, Valle , Hämäläinen, Ilanne-Parikka , Keinänen-Kiukaanniemi , Laakso, Louheranta, Rastas , Salminen & Uusitupa 2001: 1348). In a study in China to determine whether diet and exercise interventions among 577 persons aged over 25 years with impaired glucose tolerance (IGT) may delay the development of type 2 DM, and thereby reduce the overall incidence of diabetic complications, the incidence of type 2 DM was reduced by 25-50% over a 6- year period in the groups randomised by the clinic to receive diet, exercise and diet-plus-exercise compared to the control groups (Pan, Li, Hu, Wang, An, Hu, Lin, Xiao, Cao, Liu, Jiang, Wang, Zheng, Zhang, Bennett & Howard 1997:541).

Among the obese, the IGT is mainly as the result of a reduction in insulin action (Lillioja, Mott, Howard, Bennett, Yki-Jarvinen, Freymond, Nyomba, Zurlo, Swimburn & Bogardus 1988 cited by Long *et al* 1994:374). The resulting hyperglycaemia then signals increased insulin secretion, initiating a cycle leading to Beta-cell

unresponsiveness to glucose, insulin exhaustion, and then DM. Weight loss may contribute to breaking this cycle because obesity itself is a common cause of insulin resistance with multiple cellular defect most of which are reversible after proper treatment (Caro 1991 cited by Long *et al* 1994:374).

The prevalence of visual impairment and blindness was the lowest among those who reported “Yes, always” when asked whether they were trying to lose weight or not. There was a significant association between losing weight and VI and blindness ($p=0.009$) at the 0.1 level of significance. There was a significant association between VI and blindness and physical activity ($p=0.014$) at the 0.1 level of significance. The risk of those who engaged in physical activity being visual impaired is 0.51 that of those who did not. This may be because physical activity and losing weight are important in achieving good glycaemic control, which is important in the prevention of diabetic retinopathy and vision loss as well as diabetic eye diseases.

6.8.6 Health facility used for diabetes services

It was expected that most (97.7%) of the participants would be using public health facilities for their diabetes services as this was a health facility-based study. In addition, the participants were among those where booked for diabetes check-up.

6.8.7 Last date the participants checked their sugar level

Most (87.1%) of the participants in this study last checked their blood glucose < 1 month ago (Table 5.30). The time interval between blood glucose testing among the participants appears to be too long, considering that blood glucose may increase or decrease at anytime, sometimes with disastrous consequences. Frequent self-monitoring blood glucose has been associated with better glycaemic control. A consensus opinion among a group of experts from the UK suggested

that persons with type 1 DM should monitor their blood glucose at least 4 times a day. The reason for this is that type 1 DM patients are at greater risk of hypoglycaemia and hyperglycaemia. Type 2 DM patients using Insulin or oral medications should monitor their blood glucose at least once daily, varying the time of testing between fasting, pre-prandial and post-prandial glucose levels during the day (Owens, Barnett, Pickup, Kerr, Bushby, Hicks, Gadsby & Frier 2004). In a study to investigate two testing regimen of self-monitoring blood glucose among 202 patients with stable metabolic control, self-monitoring blood glucose (SMBG) once per week was found to be as sufficient as self-monitoring 4 times per week to maintain HbA1c in non-insulin treated type 2 DM close to metabolic rate (Scherbaum, Ohmann, Abholz, Dragano & Lankisch 2008).

6.8.8 Knowledge about complications of diabetes mellitus (vision problems and blindness, diabetic retinopathy and glaucoma)

Findings from this study showed that most (82.6%) of the participants knew that DM could cause vision problems and blindness (Table 5.31). This figure is higher than the 66.1% that was reported in another South African study among 106 people with diabetes aged between 30 and 85 years old (Mashige *et al* 2008:98). The percentage of those who knew that DM could cause diabetic retinopathy is also higher (74.4%) than the 42% reported in the above study. However, the percentage of those who knew that DM could cause glaucoma (53%) in the present study was similar to the one reported in the above study. However, in another South African study (Clarke-Farr *et al* 2006:138), participants who agreed/strongly agreed that DM might affect the way we see (vision problems and blindness) was higher (89%) than the 82.6% reported in the present study. The 33% of those who agreed and 44% of those who strongly agreed that DM might cause diabetic retinopathy is lower than the 74.4% reported in this study and 88% of those who agreed/strongly agreed that DM might cause pressure changes inside the eye leading to glaucoma is higher than the 53.1% reported in this study.

A higher proportion (97%) of those who agreed that DM might affect the way we see was also reported in a study in Cape Town, South Africa (Phillips *et al* 2012: 72). The percentage (62%) of those who agreed that that DM might cause bleeding and damage inside the eyes was lower than the 74.4% reported in this study (Phillips *et al* 2012: 72). The high proportion of participants who are aware that DM might lead to vision problems and blindness, diabetes retinopathy and glaucoma suggests that the participants have adequate access to information about the DM complications. Mashige *et al* (2008:98) indicated that the reason for the adequate knowledge with regard to DM types and risk factors and complications of DM is that the people with DM have easy access to advice in the medical services.

6.8.9 Knowledge about complications of diabetes mellitus and visual impairment and blindness

The knowledge and practices that patients with DM have about the disease and its complications have an effect on their compliance to treatment and successful management of the disease (Phillips *et al* 2012:74). This suggests that people with DM who are aware that DM might cause visual impairment (VI) and blindness are more likely to seek interventions to prevent VI and blindness than those who are unaware. In this study VI and blindness was not significantly associated with knowledge of DM and its complications.

6.8.10 History of eye examination

Regular eye examinations in general and among persons with DM in particular are important in the prevention of visual impairment and blindness. It has been shown that the incidence and prevalence of diabetic blindness is lower in populations where screening for diabetic eye diseases is well established compared with populations without screening (Stefansson, Bek, Porta, Larsen, Kristinson &

Agardh 2000: 377). It has also been shown that early detection and treatment of diabetic retinopathy can reduce the risk of diabetic complications such as visual impairment. It has been recommended that type 1 DM patients should have the first dilated and comprehensive eye examination by an ophthalmologist or optometrist within 3-5 years after diagnosis of DM once the patient is 10 years or older. For type 2 DM patients, the first dilated and comprehensive eye examination should be done at the time of diagnosis of DM. Thereafter, eye examinations should be done annually in both type 1 and type 2 DM patients. Less-frequent examinations (every 2-3 years) may be considered following one or more normal eye exams (American Diabetes Association 2012: s35, Fong *et al* 2003: s101).

Many (45.4%) of the participants in this study were last examined longer than a year ago. Similarly, in a study in Durban, South Africa (Mashige *et al* 2008:98) among 106 people with DM many (48.3%) of the participants last had eye examination more than a year and a half ago. This does not augur well for people with DM as regular eye examinations are one of the most important factors in the prevention of the complications of DM such as visual impairment and blindness (Mashige *et al* 2008:100). In another South African study by Mashige *et al* (2011:178) to evaluate the use of eye care services among the 1008 persons aged 60 years and older, 29.4% of the participants last visited an eye health facility less than a year ago while 20.3% last visited the facility between 1-2 years ago. This is a concern as many of the vision problems that affect the elderly population; particularly those of gradual onset, such as chronic glaucoma are usually free of symptoms. Regular eye examinations are necessary for the early detection and treatment of such conditions and prevent unnecessary visual impairment and blindness.

6.8.10.1 History of eye examination as a risk factor for visual impairment and blindness

The prevalence of visual impairment and blindness was significantly higher among those who were last examined longer than a year ago, compared to those who were last examined less than a year ago ($p=0.059$) (Table 5.32). This indicates that the participants have not been complying with the recommendation of having annual dilated and comprehensive eye examinations. In a study in Yemen among 694 people with DM aged 13-95 years, regular visits to medical clinics was identified as a proxy indicator of better primary prevention of DM eye complications. Participants with irregular clinic visits were found to be at higher risk of bilateral visual impairment and blindness than those with regular visits. Other specific factors, such as lack of screening facilities, poor patient education, living in remote areas from cities and lack of health insurance may all have contributed to the high rate of diabetic complications including visual impairment (Al-Akily *et al* 2011:835).

The reason for the non-compliance to regular eye examinations may be lack of knowledge about the importance of these examinations; lack of availability, accessibility and affordability of eye care services (discussed above). In a study in South Africa among 73 people with DM, Phillips *et al* (2012:75) cited denial, negligence or apathy on the part of the patients as some of the reasons of non-compliance to regular eye examinations. These authors added that good knowledge about DM and the importance of regular eye examinations is not associated with better outcomes in terms of compliance.

6.8.11 Family history of diabetes mellitus

The prevalence of DM has been found to be significantly associated with family history of DM, among other factors. In a study in South

Africa to determine the prevalence of DM, impaired glucose tolerance, impaired fasting glucose and associated risk factors among adults aged > 15 years, family history of DM was found to be a risk factor for DM ($p=0.014$, OR, 3.48, 95%CI, 1.29-9.43) (Motala, Esterhuizen, Gouws, Pirie & Omar 2008:1785). In the WESDR study in the USA among 1370 type 2 DM patients, insulin users were more likely to be having a family history of DM (65.7% versus 59.8%) than non-insulin users. Family history of DM was not associated with the presence and severity of diabetic retinopathy (Klein *et al* 1984:528). This is probably because insulin users are likely to be having type 1 DM, which is mainly an inherited condition. In a study in Ahmedabad, India to highlight the magnitude and determinants of DR and other ocular complications among 13887 persons with DM, family history of DM was individual associated with the presence of diabetic retinopathy (OR=1.32) (Vyas *et al* 2009:603). In this study, over half (52.7%) of the participants had family history of DM and about a third (31.6%) of the family members with DM had visual impairment. There was however no significant association between VI and blindness and family history of DM ($p=0.305$).

6.8.12 Hypertension

Hypertension is a common condition in South Africa and is considered as a risk factor for heart attacks, stroke, left ventricular hypertrophy, renal disease and blindness. It is frequently referred to as a “silent epidemic” in South Africa, probably because the affected individuals are usually unaware that they have the condition, unless they have their blood pressure checked in health facilities (Steyn, Fourie & Temple (eds) 2006:80). Data from the South Africa demographic and health survey, 2003 showed that the prevalence of hypertension among South African men and women was 40% and 51%, respectively. The prevalence was higher among men living in the urban areas (45%) compared to those living in the rural areas (21%). Similarly, the prevalence among women living in the urban areas (50%) was higher than those living in the rural areas (41%).

The prevalence of hypertension among men and women in the Limpopo Province was 46% and 39%, respectively (Department of Health, Medical Research Council 2007).

Previous studies have found hypertension to be a risk factor for the development of type 2 DM. In a prospective study in the United States among 12550 non-diabetic adults aged between 45 and 64 years to determine whether there was an independent relationship between the use of antihypertensive medication and the risk of the subsequent development of type 2 DM, type 2 DM was almost 2.5 times as likely to develop in subjects with hypertension as in subjects with normal blood pressure. After accounting for the excess risk of DM in subjects with hypertension, those who took a thiazide diuretic, ACE (Angiotensin-converting enzyme) inhibitor or calcium-channel antagonist were not at increased risk of DM. However, those who took beta-blockers were 28% at greater risk of DM than those who took no medication, without regard to the presence or absence of hypertension, socio-demographic characteristics, health-related behavior, family history with respect to DM, and a variety of coexisting conditions (Gress, Nieto, Shahar, Wofford & Brancati 2000: 911).

In a study in Taiwan among 11478 adults aged 40 years and older to elucidate the relationship between hypertension and type 2 DM, the age- and sex- adjusted prevalence of hypertension was found to be twice that of non-diabetic patients (Tai, Chuang, Chen, Lin 1991:1015). The prevalence (78.8%) of hypertension among the participants in this study was higher than that reported in other studies. In a study in Jordan among 986 diabetic patients aged between 9 and 86 years, the prevalence was 59.8% (Al-Bdour, Al-Till, MI & Abu Samra 2008) and in a study in Iran among 634 people with DM aged 25 to 64 years, the prevalence of hypertension was 39.6% (Javadi *et al* 2009). In a study in Hlabisa District, South Africa among people with DM aged 21-81 years, the prevalence of hypertension was found to be 65.4% (Rotchford & Rotchford 2002:

538) A similar percentage (65%) was reported in another South African study among 73 people with DM aged 33-80 years (Phillips *et al* 2012:72). The reason for the differences may be due to differences in the methodologies, age, populations studied etc.

6.8.12.1 Hypertension as a risk factor for VI and blindness

Previous studies have found a significant association between hypertension and diabetic retinopathy (DR), VI and blindness. In the Wisconsin Epidemiologic Study of Diabetic Retinopathy (WESDR) in the USA to describe the relationships between the presence and severity of DR and associated risk factors among 1370 type 2 diabetic patients, higher systolic blood pressure (BP) was found to be significantly associated with the presence of DR in persons with DM for <15 years. Furthermore, a relationship was found between BP and severity of DR independent of other risk factors (Klein *et al* 1984:531). In another WESDR study among 996 type 1 DM patients, patients who had been diabetic for < 10 years, who were in the highest quartile for diastolic BP were 1.5 to 2 times as likely to have retinopathy as those in the lowest quartile for this variable. Among patients who had been diabetic for ≥ 10 years, significant association ($p < 0.05$) was found between the presence of proliferative retinopathy and high systolic BP (Klein *et al* 1984:524). In another study in Los Angeles, California to identify the biologic risk factors associated with having DR among 6357 Latinos with type 2 patients aged ≥ 40 years, a higher risk of PDR was found in persons with systolic of ≥ 150 mmHg compared with those with lower systolic BP (Varma, Macias, Torres, Klein, Peña, Azen, Los Latino Eye Study Group 2007:1335).

In a study among 986 Jordanian people with DM, a significant association was shown between hypertension and non-proliferative diabetic retinopathy ($p = 0.005$) and maculopathy ($p < 0.001$), but not with proliferative diabetic retinopathy ($p = 0.058$) (Al-Bdour *et al* 2008). The presence of hypertension was also found to be

significantly associated with VI ($p=0.015$) in a study among 1414 people with DM in Chennai metropolis, India (Rani *et al* 2012).

The prevalent of visual impairment and blindness was higher among participants with hypertension than among those without. However, no significant association was found between hypertension and VI and blindness in this study ($p=0.652$). The higher prevalence of VI and blindness among those with hypertension is in agreement with the findings from a study in Iran, where the prevalence of VI was found to be significantly higher among hypertensive patients (20.3%) than among non-hypertensive ones (5.5%) (Horri *et al* 2011).

The crude prevalence of VI among insulin and non-insulin users with high blood pressure was higher than among those without (Saaddine *et al* 2002). The reason for the higher prevalence of visual impairment and blindness among those with hypertension than those without may be that the majority (78.8%) of participants in this study had hypertension.

6.8.13 Smoking status

The majority (80.6%) of participants in this study had never smoked cigars, cigarettes or pipe of tobacco (Figure 5.28). This figure was higher than what was reported in some previous studies. In a study in the USA to examine the prevalence and correlates of visual impairment (VI) among US adults with and without DM aged ≥ 20 years, the prevalence of those who never smoked was 45.9% (Zhang *et al* 2008:1423). In a study in Sweden among 1769 diabetes patients, 69.5% reported they were non-smokers and 30.5% were smokers (Henricsson *et al* 1996:535).

The reason for the high proportion of those who never smoked in this study may be that there were more females than males in this study, and studies have shown that the proportion of females of smoke is lower than that of males. Data from the South African demographic and health survey (SADHS) 1998 showed that there

were more males (52.6%) than females (24.4%) among those who ever smoked, similarly there were more males (36.7%) than women (9.4%) among current smokers [Department of Health (DoH), Medical Research Council (MRC) 2002]. The fact that this study was done in the rural area may also explain the high proportion of non-smokers among the participants. The prevalence of current smokers among women was found to be 11.5% and 6.1%, in urban and rural areas, respectively and that for men was 38% and 34.4% in the urban and rural areas, respectively (DoH, MRC 2002).

6.8.13.1 Smoking as a risk factor for visual impairment and blindness

Smoking has been considered to be a major threat to health and has also been associated with visual impairment and blindness by some authors. According to Penn & Synder (1993) cited by Oduntan & Mashige (2011: 196), cigarette smoke is a very rich source of free radicals (oxidants) and is highly oxidising, putting an oxidative stress on the entire organism and on the lungs and has been considered to be the most important environmental risk factor for age-related macular degeneration. Oxidative stress, which is defined as an imbalance between oxidants and antioxidants in favour of oxidants, potentially leading to tissue damage, has been implicated in the pathogenesis of several eye conditions such as corneal disease, cataract, diabetic retinopathy and retinitis pigmentosa (Oduntan & Mashige 2011:192).

The prevalence of VI and blindness was not associated with smoking status in this study. This finding is in agreement with what was reported in other studies. In a study in the USA among 3391 people with DM, the crude prevalence of visual impairment among current smokers (24.1%) using insulin was lower than that of non-smokers (29.2%); the prevalence among current smokers (22.8%) not using insulin was similar to that of non-smokers (22.6%). However, visual impairment was not significantly with smoking status (Saaddine et al

1999:1202). In a study in Southern Sweden among 1769 DM patients, the prevalence of VI and blindness among non-smokers (2.5%) was higher than that among smokers (0.6%); however smoking was also not found to be a significant risk factor of VI (Henricsson *et al* 1996:535). In contrast, a significant association was found between smoking and diabetic retinopathy in other studies. In a study in Brazil to determine the prevalence of DR and its risk factors in 437 type 1 DM outpatients aged >18 years, current or past smoking history was associated with DR ($P < 0.001$). In addition, smoking increased the chances for advanced DR by 2.75 times (OR 95%CI 1.15-6.60). Current smoking was also associated with clinically significant macula oedema (OR 3.19, 95%CI 1.24-8.2, $P = 0.012$) (Esteves, Kramer, Azevedo, Stolz, Roggia, Larangeira, Miozzo, Rosa, Lambert, Pecis, Rodrigues & Canani 2009:271).

6.8.14 Accessibility of the public health facility and visual impairment and blindness

Availability and accessibility of health facilities have been associated with increased utilisation of the health services, including eye care services. Ntsoane and Oduntan (2010:182) indicated that the three main reasons for the high prevalence of visual impairment in many countries are non-availability, non-accessibility and non-affordability of eye care services. Accessibility of eye care services has been defined as the travel time required by the public transportation to reach the nearest eye care provider (Silva *et al* 2002:271). In a study in Rural India to investigate services uptake in population served by outreach eye camps and to identify barriers to uptake, persons living 3km or less from the eye camp were more likely to attend than those living farther away (OR, 4.5; 95%CI, 1.7-12.5) (Fletcher *et al* 1999:1395).

The availability and accessibility of health services in South Africa vary from province to province, district to district and from community to community. This is largely due to the past apartheid

policies, which promoted inequities in the access to economic and social resources, including health services. Access to health services is much better in provinces such as Gauteng and the Western Cape compared to provinces such as Limpopo, North-West, Eastern Cape and Kwazulu Natal, which were previously under-resourced and marginalised during the apartheid era. Even with a province, accessibility is better in the urban areas than in the rural areas. Even within a community, people who are wealthy have better access to health services than those who are poor (McIntyre & Gilson 2002).

Immediately after the democratically elected government came into power in 1994, a range of policies to redress the inequity of the past and to ensure access to primary health services were initiated. For instance, the funding for the previously under-resourced and marginalised provinces [Northern Province (now Limpopo Province), North-West, Eastern Cape, KwaZulu Natal) were increased and between April 1993 and September 1997, 393 clinics were built and an additional 152 clinics were extended (Ntsaluba & Pillay 1998:33). These initiatives have undoubtedly increased the availability of health facilities in many areas where they did not exist, however accessibility of many health services, including eye care services especially in the rural areas remain a challenge.

Most (89.5%) of the participants in this study lived < 1 hour walk from public health facilities (Figure 5.30), suggesting an improved access to the facilities. However, optometry services were available in only two of the seven public health facilities visited and there are no ophthalmological services were in the all the public services in the Mopani District. People requiring cataract surgeries have to be transferred to public health facilities in other districts (Elim or Mankweng hospital) situated about 150km from where this study was conducted. It is not surprising that only 4432 people had cataract operation in 2006 in the whole of the Limpopo Province with about 4,7 million people dependent of the public sector for eye care

(Leucona & Cook 2011:510). This suggests that eye care services are still inaccessible to many poor people in the rural areas of the Limpopo Province.

The prevalence of VI and blindness was insignificantly higher (16%) among participants who lived closer to health facilities than those living far from the facilities (Figure 5.31). A major reason for this finding is that there were more participants in the former (37.4 %) than in the latter (8.7 %) (Figure 5.30). The fact that there was no access to ophthalmological services in the public health facilities in the Mopani District, may explain the higher prevalence of VI and blindness due to cataract. Even in the facilities where optometry services were available, it was alleged that the waiting period to receive spectacles could be as long as 6 months. This may also explain the high prevalence of VI (before optical correction) due to refractive error.

6.9 LIMITATIONS OF THE STUDY

Limitations for this study include the following:

- i. The fact that this study was conducted in public health facilities and not population-based could have introduced a health-seeking bias.
- ii. The ideal methodology to obtain data on the prevalence and causes of visual impairment and blindness among the participants would have been to conduct a comprehensive eye examination that included a thorough objective and subjective refraction, dilated fundus examination, and visual field measurements. Due to logistical and financial constraints, these were not done; instead, auto-refraction results and a pinhole test were used to determine the aided visual acuity. However, it is unlikely that there would be a significant difference in prevalence of VI in this study even if the ideal method had been used.

- iii. The fact that visual impairment was determined based on visual acuities only might have excluded those who were visually impaired due to visual field loss, and thus underestimate the prevalence of visual impairment.
- iv. Some subtle causes of visual impairment may not have been properly identified because a direct ophthalmoscope rather than indirect (with pupil dilation) one was used to examine the retina.

6.10 CONTRIBUTIONS OF THE STUDY

Despite the limitations highlighted above, this study, which is considered to be the first to describe the prevalence of visual impairment and blindness among Black South Africans with DM in a predominantly rural district of Limpopo Province, provides valuable insight into the magnitude of the problem in the community. This study provides data on the prevalence of both uncorrected and corrected visual impairment for a population on which there is little previous data. In addition to the prevalence, the causes of visual impairment and blindness have been documented. This study showed that the very high prevalence of VI and blindness in this population was due to cataract and refractive error, and not due to diabetes itself. This indicates a need for the health authorities to improve cataract surgery and optometric services in this community. The health authorities can therefore use findings from this study in the planning for eye care delivery in general and among people with DM in particular. It is envisaged that eye care practitioners would appreciate the findings of the study with regard to the extent of visual impairment and blindness among the people with DM in the targeted district as well as the risk factors associated with these conditions among Black adults 40 years and older in the Limpopo Province. The fact that the pathogenesis of diabetes is the same regardless of where a person lives, suggests that data from this study can be generalised to other populations with diabetes, especially those living in rural areas.

6.11 CONCLUSION

The aim of this study was to determine the prevalence and causes of visual impairment and blindness among Black South Africans with diabetes in Mopani District, Limpopo province. The prevalence of visual impairment and blindness among the participants was relatively high and the sad reality is that the majority of the visual impairment was due to non-diabetic eye conditions, including refractive errors and cataract. About 84% of the participants were visually impaired due to one or both of these treatable conditions and only 3.8% due to diabetic retinopathy. This indicates that a lot still needs to be done to eliminate the causes of avoidable in South Africa

6.12 RECOMMENDATIONS

It is there recommended that appropriate and affordable refraction and cataract surgical services should be made available and accessible to this rural population of the Limpopo Province. In addition, awareness campaigns that target the poor and illiterate should be established to educate them about the causes of visual impairment and blindness, including refractive error and cataract, as well as the available treatment. It is also recommended that a population-based study be conducted to provide accurate data on the prevalence and causes of visual impairment and blindness among persons with DM in the Limpopo Province of South Africa.

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Annexure A: Interview schedule (Record form)*General information*

Examination Date

Participant number

Name of the hospital / Clinic visited

- ☐ 1. Carlota clinic
- ☐ 2. Ga-kgapane Hospital
- ☐ 3. Ga –kgapane clinic
- ☐ 4. Letaba Hospital
- ☐ 5. Dan clinic
- ☐ 6. Nkowankowa health centre
- ☐ 7. Tzaneen clinic

Participant's name:

Participant number:

Age:

Sex: 1: male 2: female

Occupation:

SECTION A: VISION ASSESSMENT

A1: Is the Participant wearing refractive optical correction

- ☐ 1. Yes
- ☐ 2. No [skip to A3]

A2: Visual acuity with refractive optical correction

Right eye left eye

Visual acuity cannot be determined (reason)

A3: Visual acuity (for those not wearing any correction)

Right eye left eye

Auto- refraction results

	sphere	cylinder	axis
Right eye			
Left eye			

A4: Aided visual acuity

Right eye left eye

A5: Cause of visual impairment (please tick)

- ☐ 1. Cataract
- ☐ 2. Corneal opacity
- ☐ 3. Diabetic retinopathy
- ☐ 4. Glaucoma
- ☐ 5. Refractive error
- ☐ 6. Other
- ☐ 7. amblyopia
- ☐ 8. Cataract & refractive error
- ☐ 9. Glaucoma & refractive error
- ☐ 10. Corneal opacity & refractive error
- ☐ 11. Corneal opacity & cataract
- ☐ 12. Diabetic retinopathy & refractive error
- ☐ 13. Amblyopia & refractive error

SECTION B: ANTHROPOMETRIC MEASUREMENTS

B1: Body Mass Index (BMI) = $\frac{\text{Weight}}{\text{Height}^2} = \dots\dots\dots (\text{Kg/m}^2)$

B2: Waist Circumference = cm

SECTION C: INTERVIEW SCHEDULE

SOCIO-DEMOGRAPHIC CHARACTERISTICS

Question 1: What is your marital Status?

- ☐ 1: Single
- ☐ 2: Married
- ☐ 3: Divorced/separated
- ☐ 4: Widowed

Question 2: To which ethnic group do you belong?

- ☐ 1: Shangaan
- ☐ 2: Sotho
- ☐ 3: Venda
- ☐ 4: Other (specify).....

Question 3: What is your highest educational qualification?

- ☐ 1. No education
- ☐ 2. Primary school
- ☐ 3. High school
- ☐ 4. Tertiary qualification

Question 4: What is your personal monthly Income?

- ☐ 1. No income
- ☐ 2. R0-R500
- ☐ 3. R501-R1000
- ☐ 4. R1001-R2000
- ☐ 5. R2000 and higher

Question 5: What is the source of your household income?

- ☐ 1. No income
- ☐ 2. Informal employment
- ☐ 3. Formal employment
- ☐ 4. Government social grants
- ☐ 5. Pension

Question 6: How will you describe your residence?

- ☐ 1. Rural
- ☐ 2. Informal settlement
- ☐ 3. Semi-urban
- ☐ 4. Urban
- ☐ 5. Other (please state).....

DIABETES

“The following questions relate to diabetes”

Question 7: When was the first time that you were told by a doctor or other health professional that you have diabetes?

- ☐ 1. Less than 5 years ago
- ☐ 2. 5-10 years ago
- ☐ 3. 11-15 years ago
- ☐ 4. 16-20 years ago
- ☐ 5. More than 20 years ago
- ☐ 9. I don't know/unsure

Question 8: How many types of diabetes do you know?

- ☐ 1. One type
- ☐ 2. Two types
- ☐ 3. Three types
- ☐ 4. Other (specify).....
- ☐ 9. I don't know/unsure (**skip to Q.10**)

Question 9: What type of diabetes do you have?

- ☐ 1. Type 1 (Insulin dependent)
- ☐ 2. Type 2 (non-insulin dependent)
- ☐ 3. Other (specify).....
- ☐ 9. I don't know/unsure

Question 10: What treatment/s or medical recommendations have been prescribed for your diabetes?

- | | | |
|---|---------------------------------|---|
| <input type="checkbox"/> 10.1. Insulin inject | <input type="checkbox"/> 1.Yes | <input type="checkbox"/> 2. No [skip Q.11] |
| <input type="checkbox"/> 10.2. Pills | <input type="checkbox"/> 1.Yes | <input type="checkbox"/> 2. No [skip Q.12] |
| <input type="checkbox"/> 10.3. Special diet | <input type="checkbox"/> 1. Yes | <input type="checkbox"/> 2. No [skip Q.13] |
| <input type="checkbox"/> 10.4. Lose weight | <input type="checkbox"/> 1. Yes | <input type="checkbox"/> 2. No [skip Q.14] |

- ☐ 10.5. Regular physical activity ☐ 1. Yes ☐ 2. No
[skip Q.15]

Question 11: If insulin has been prescribed for your diabetes, do you take the treatment as prescribed?

- ☐ 1. Yes, Always
☐ 2. Yes, but not always
☐ 3. I don't take the treatment at all

Question 12: If pills have been prescribed for your diabetes, do you take the treatment as prescribed?

- ☐ 1. Yes, Always
☐ 2. Yes, but not always
☐ 3. I don't take the treatment at all

Question 13: If special diet has been recommended for your diabetes, do you follow a special diet?

- ☐ 1. Yes, Always
☐ 2. Yes, but not always
☐ 3. I don't follow special diet at all

Question 14: If losing weight has been recommended for your diabetes, are you trying to lose weight?

- ☐ 1. Yes, Always
☐ 2. Yes, but not always
☐ 3. I don't try losing at all

Question 15: If physical activity has been recommended for your diabetes, are you doing physical activity?

- ☐ 1. Yes, Always

- ☐ 2. Yes, but not always
- ☐ 3. I don't do physical activity at all

Question 16: Where do you usually check your blood sugar?

- ☐ 1. Public hospital, clinic or health centre
- ☐ 2. Private doctor or private clinic
- ☐ 3. Family member or friend
- ☐ 4. I check myself
- ☐ 5. I check at another place [**please state**]
- ☐ 6. I don't check at all [**skip to 19**]

Question 17: When was the last time that you had your blood sugar level checked?

- ☐ 1. Less than a week ago
- ☐ 2. Less than a month ago
- ☐ 3. Less than six months ago
- ☐ 4. Less than a year ago
- ☐ 5. Longer than a year ago
- ☐ 9. I don't know/unsure

Question 18: Are you aware that diabetes can lead to vision problems and blindness?

- ☐ 1. Yes
- ☐ 2. No

Question 19: Do you know that diabetes can cause damage to the blood vessels of the retina causing diabetic retinopathy?

- ☐ 1. Yes

- ☐ 2. No

Question 20: Do you know that diabetes can cause glaucoma (an increase in eye pressure that can lead to blindness if untreated)?

- ☐ 1. Yes

- ☐ 2. No

Question 21: Have you ever had your eyes examined by an Ophthalmologist or Optometrist?

- ☐ 1. Yes

- ☐ 2. No [*skip to 23*]

- ☐ 9. I don't know/unsure [*skip to 23*]

Question 22: When was the last time that you had your eyes examined by an Ophthalmologist or Optometrist?

- ☐ 1. Less than a week ago

- ☐ 2. Less than a month ago

- ☐ 3. Less than six month ago

- ☐ 4. Less than a year ago

- ☐ 5. Longer than a year ago

- ☐ 9. I don't know/unsure

Question 23: Do any of your immediate family members (blood relatives) have diabetes?

- ☐ 1. Yes

- ☐ 2. No [*skip to 25*]

- ☐ 9. I don't know/unsure [*skip to 25*]

Question 24: Are any of your blood relatives with diabetes blind or visually impaired (not seeing well)?

- ☐ 1. Yes
- ☐ 2. No
- ☐ 9. I don't know/unsure

HYPERTENSION

“ The following questions are related to hypertension or High blood pressure”

Question 25: When was the last time you had your blood pressure checked?

- ☐ 1. Less than a week ago
- ☐ 2. Less than a month ago
- ☐ 3. Less than six month ago
- ☐ 4. Less than a year ago
- ☐ 5. Longer than a year ago
- ☐ 9. I don't know/unsure

Question 26: Has a doctor or other health professional ever told you that you have high blood pressure?

- ☐ 1. Yes
- ☐ 2. No [***skip to Q. 34***]
- ☐ 9. I don't know/unsure [***skip to Q.34***]

Question 27: Has any treatment or medical recommendation been prescribed for your high blood pressure?

- ☐ 1. Yes

- ☐ 2. No [**skip to Q.33**]

Question 28: What treatment/s or recommendation/s has been prescribed for your high blood pressure?

- | | |
|---|--|
| <input type="checkbox"/> 28.1 Pills | <input type="checkbox"/> 1.Yes <input type="checkbox"/> 2. No [skip Q.29] |
| <input type="checkbox"/> 28.2 Special diet | <input type="checkbox"/> 1.Yes <input type="checkbox"/> 2. No [skip Q.30] |
| <input type="checkbox"/> 28.3 Physical activity | <input type="checkbox"/> 1.Yes <input type="checkbox"/> 2. No[skip Q.31] |
| <input type="checkbox"/> 28.4 Lose weight | <input type="checkbox"/> 1. Yes <input type="checkbox"/> 2. No [skip Q.32] |

Question 29: If pills have been prescribed for your high blood pressure, do you take the pills as prescribed?

- ☐ 1. Yes, always
- ☐ 2. Yes, but not always
- ☐ 3. I don't take pills at all

Question 30: If special diet has been prescribed for your high blood pressure, do you follow special diet as prescribed?

- ☐ 1. Yes, always
- ☐ 2. Yes, but not always
- ☐ 3. I don't follow special diet at all

Question 31: If physical activity has been prescribed for your high blood pressure, do you participate in physical activity as recommended?

- ☐ 1. Yes, always
- ☐ 2. Yes, but not always
- ☐ 3. I don't participate in physical activity at all

Question 32: If losing has been prescribed for your high blood pressure, are you trying to lose weight as recommended?

- ☐ 1. Yes, always
- ☐ 2. Yes, but not always
- ☐ 3. I don't try to lose weight at all

SMOKING

"The following questions relate to smoking habit"

Question 33: Do you smoke or have you ever smoked cigarettes, cigars, or pipes of tobacco in your life?

- ☐ 1. Never smoked [**skip to Q.37**]
- ☐ 2. Smoked occasionally
- ☐ 3. Smoked regularly
- ☐ 4. Always smoked

Question 34: How old were you when you started smoking?
-----years

Question 35: How often do you smoke currently?

- ☐ 1. Daily [**Skip Q.36**]
- ☐ 2. Regularly [**Skip Q.36**]
- ☐ 3. Occasionally [**Skip Q.36**]
- ☐ 4. I don't smoke currently

Question 36: If you don't smoke currently, for how long have you stopped smoking?

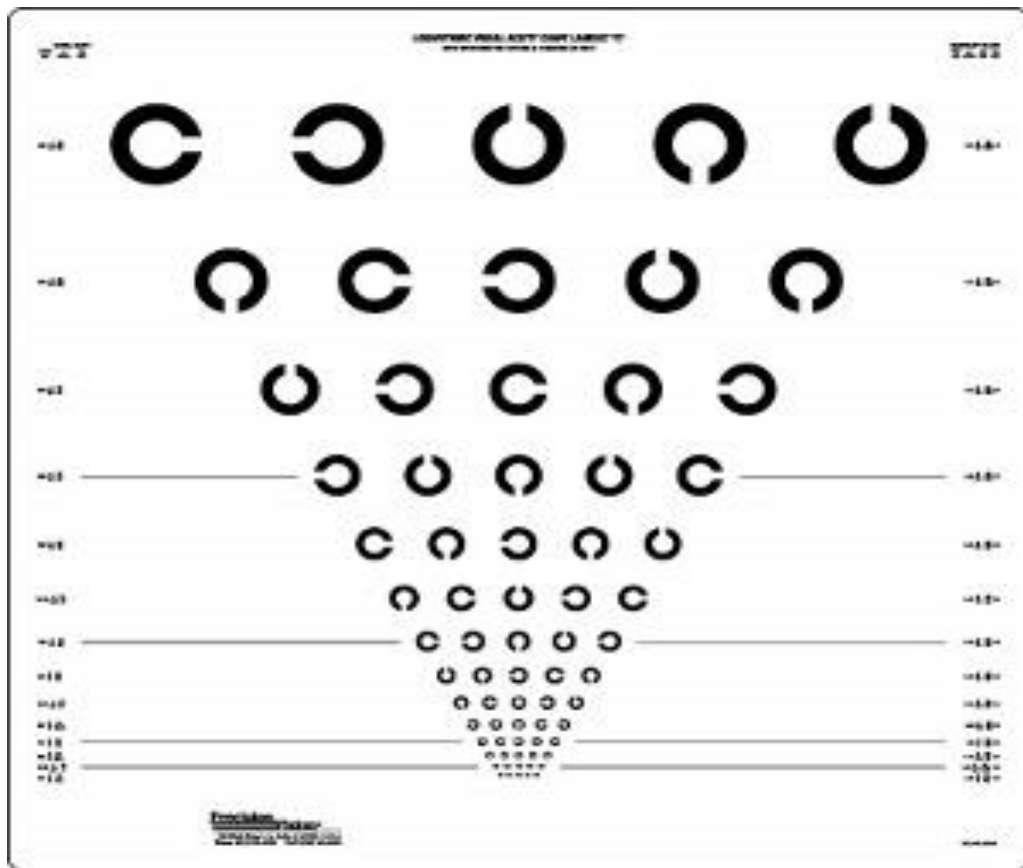
- ☐ 1. Less than a week ago
- ☐ 2. Less than a month ago

- ☐ 3. Less than six month ago
- ☐ 4. Less than a year ago
- ☐ 5. Longer than a year ago
- ☐ 9. I don't know/unsure

ACCESSIBILITY TO HEALTH FACILITIES

Question 37: How far do you live from public health facilities (Clinic, health, or hospital)?

- ☐ 1. Less than 15 minutes walk
- ☐ 2. Less than 30 minutes walk
- ☐ 3. Less than 1 hour walk
- ☐ 4. Longer than an hour long
- ☐ 9. I don't know/ unsure



Annexure B: LogMAR visual acuity chart (Landolt "C").



Annexure C: CRK7000 Auto-refractor

Annexure D: Application for approval to conduct a study

UNIVERSITY OF SOUTH AFRICA ETHICS COMMITTEE

APPLICATION FOR APPROVAL TO CONDUCT A STUDY ON HUMAN PARTICIPANTS

PROJECT TITLE:

PROJECT LEADER:

DECLARATION

I, the signatory, hereby apply for approval to conduct a study described in the attached protocol and declare that:

1. I am fully aware of the contents of the Guidelines on Ethics for Medical Research and I will abide by the guidelines as set out in that document.
2. I undertake to provide all the necessary information to every person who participates in the stipulated project (Annexure F). Every Participant will be requested to sign a consent form (Annexure G)

Name of Researcher:

Signature:

Date:

For Official use by the Ethics Committee:

Approved/Not approved

Remarks:

Signature of Chairperson:

Date

CLEARANCE CERTIFICATE

PLEASE QUOTE THE PROJECT NUMBER IN ALL ENQUIRES

Annexure F: Letter seeking consent from Department of Health: Limpopo

P O BOX 7202
TZANENG MALL
0855
2011-02-25

The Head of Department
Department of health: Limpopo province
Private Bag X9302
Polokwane
0700

APPLICATION FOR A PERMISSION TO CONDUCT A STUDY

I, Raymond Mabaso, hereby apply for a permission to conduct research in your hospital. I am a qualified Optometrist who has been practising optometry for over 20 years.

Project title: Blindness and visual impairment among Black South Africans with diabetes 40 years and older in Limpopo Province

The purpose of this study is to identify and describe the causes and prevalence of blindness and visual impairment among people with diabetes 40 years and older in Limpopo Province. Findings from this study will help to recommend appropriate intervention programs from an informed position.

- Participants will be black diabetic adults of both sexes, with age ranging from 40 years and older
- There is no risk factor associated with this study. All tests to be performed on the participants are within the scope of optometry in South Africa
- An advantage is that the participants will have an opportunity of having their eyes examined during this study.

Thanking you in anticipation
Raymond Mabaso (Research student)

Annexure G: Approval from Department of Health: Limpopo



LIMPOPO

PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH & SOCIAL DEVELOPMENT

Enquiries: Selamolela Donald

Ref: 4/2/2

07 February 2011
Mabaso R
University of South Africa
Pretoria
0001

Dear Sir

Re: Permission to conduct the study titled: Study of blindness and visual impairment among black diabetics of 40 years and older in Limpopo, South Africa

1. The above matter refers.
2. The permission to conduct the above mentioned study is hereby granted.
3. Kindly be informed that:-
 - Further arrangement should be made with the targeted institutions.
 - In the course of your study there should not be any action that will disrupt the services
 - After completion of the study, a copy should be submitted to the Department to serve as a resource
 - The researcher should be prepared to assist in the interpretation and implementation of study recommendation where possible

Your cooperation will be highly appreciated

Head of Department
Health and Social Development
Limpopo Province

Annexure H: Letter requesting permission to conduct the study

P O BOX 7202
TZANENG MALL
0855
2011-02-25

The Chief Executive Officer
Dr CN Phathudi Hospital
Private Bag X4056
Tzaneen
0850

Dear Madam

APPLICATION FOR A PERMISSION TO CONDUCT RESEARCH

I, Raymond Mabaso, hereby apply for approval to conduct research in your hospital. I am a qualified Optometrist who has been practising optometry for over 20 years.

PROJECT TITLE: BLINDNESS AND VISUAL IMPAIRMENT AMONG BLACK PEOPLE WITH DIABETES 40 YEARS AND OLDER IN LIMPOPO PROVINCE, SOUTH AFRICA.

The purpose of this study is to identify and describe the causes and prevalence of blindness and visual impairment among people with diabetes 40 years and older in Limpopo Province. Findings from this study will help to recommend appropriate intervention programs from an informed position.

- Respondents will be black diabetic adults of both sexes, with age ranging from 40 years and older
- There is no risk factor associated with this study.
- An advantage is that the respondents will have an opportunity of having their eyes examined during this study.

Thanking you in anticipation

RAYMOND MABASO(Research student)

Annexure I: Approval to conduct the study



LIMPOPO

PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

**DEPARTMENT OF HEALTH AND SOCIAL DEVELOPMENT
DR C.N PHATHUDI DISTRICT HOSPITAL
PRIVATE BAG X4056
TZANEEN
0850**

REF: S5/2/3
ENQ: MOHALE M.P/MAAKE L.C
TEL: 015 355 8000
FAX: 015 355 3434

23/03/2011

**TO: MR MABASA RAYMOND
P.O BOX 7202
TZANENG MALL
0855**

**PERMISSION TO CONDUCT RESEARCH ON BLINDNESS AND VISUAL
IMPAIRMENT AMONG BLACK DIABETICS OF 40 YEARS AND OLDER IN
LIMPOPO, SOUTH AFRICA.**

1. The above matter refers.
2. The permission to conduct the above mentioned study is hereby granted.
3. Kindly be informed that.
 - In the course of your study there should not be any action that will disrupt the services.
 - After completion of the study a copy should be submitted to the office of CEO to serve as a resource.
 - You should be prepared to assist in the interpretation and implementation of study recommendation where possible.

Your cooperation will be highly appreciated

M. Babinkele
.....
CHIEF EXECUTIVE OFFICER

2011.03.23....
DATE

Annexure J: Letter requesting permission to conduct the study

P O BOX 7202
TZANENG MALL
0855
2011-02-25

The Chief Executive Officer
Letaba Hospital
Private Bag X1430
Letaba 0870

Dear Sir

APPLICATION FOR A PERMISSION TO CONDUCT RESEARCH

I, Raymond Mabaso, hereby apply for approval to conduct research in your hospital. I am a qualified Optometrist who has been practising optometry for over 20 years. I am currently registered for a D Litt et Phil degree with UNISA.

Project title: Blindness and visual impairment among Black people with diabetes 40 years and older in Limpopo Province, South Africa.

The purpose of this study is to identify and describe the causes and prevalence of blindness and visual impairment among people with diabetes 40 years and older in Limpopo Province. Findings from this study will help to recommend appropriate intervention programs from an informed position.

- Respondents will be black diabetic adults of both sexes, with age ranging from 40 years and older.
- Eye tests and interviews will be used to collect data from the respondents. All eye tests to be done are within the scope of optometry in South Africa.
- There is no risk factor associated with this study; instead respondents will have an opportunity of having their eyes examined during the study.

Raymond Mabaso (Research student)

Annexure K: Approval to conduct the study

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF HEALTH AND SOCIAL DEVELOPMENT

LETABA PROVINCIAL HOSPITAL

Private Bag X1430
Letaba
0870

Ref: 4/2/2
Enq: Mabuza MF
Date: 22 March 2011

Mabaso R
P.O. Box 7202
Tzaneen Mall
0855

**RE: APPROVAL FOR CONDUCTING A RESEARCH ON BLINDNESS AND VISUAL
IMPAIRMENT AMONG BLACK DIABETES 40YEARS OLDER IN LIMPOPO
PROVINCE. SOUTH AFRICA: YOURSELF**

1. The above matter refers
2. You are granted permission to conduct the above research at Letaba Provincial Hospital as per permission granted by the Head of Department, Limpopo Department of Health and Social Development, on the 07th February 2011
3. Hoping that you will find this to be order

CHIEF EXECUTIVE OFFICER
Letaba Provincial Hospital

Annexure L: Information for the participants

Project title: Blindness and visual impairment among black people with diabetes 40 years and older in Limpopo Province, South Africa.

Researcher's name: Mr. R.G. Mabaso

Promoter's name: Prof. Oduntan

1. You are invited to participate in the above-mentioned research project.
2. The purpose of this study is to identify and describe the causes and prevalence of blindness and visual impairment among people with diabetes 40 years and older in Limpopo Province. Findings from this study will help to recommend appropriate intervention programs from an informed position.
3. Participation in the project is voluntary and you are free to withdraw from the project (without providing any reasons) at any time.
4. It is possible that you will not personally benefit from being a Participant in this project, but the knowledge that will be accumulated through the project might prove advantageous to others.
5. You are encouraged to ask any questions that you might have in connection with this project at any stage. The project leader and his/her staff will gladly answer your questions. They will also discuss the project in detail with you.
6. There is no risk factor associated with your participation in this project. The advantage is that you will have an opportunity to have your eyes examined.

Annexure M: Consent form

Project title: Blindness and visual impairment among black people with diabetes 40 years and older in Limpopo province, South Africa

Researcher's name: Mr. R.G. Mabaso

Promoter's name: Prof. Oduntan

- I have read the Participant Information Sheet and the nature and purpose of the research project has been explained to me. I understand and agree to take part.
- I understand the purpose of the research project and my involvement in it.
- I understand that I may withdraw from the research project at any stage and that this will not affect my status now or in the future.
- I understand that while the information gained during the study may be published, I will not be identified and my personal results will remain confidential.

Name of the Participant:

Signed.....**Date**.....

I have provided information to the research participant about the research project and I believe that he/she understands what is involved.

Researcher's signature **date**.....

Annexure N: Letter from the editor

To whom it may concern

2012-10-29

Hereby I confirm that the following thesis:

**BLINDNESS AND VISUAL IMPAIRMENT AMONG PEOPLE WITH
DIABETES 40 YEARS AND OLDER IN LIMPOPO PROVINCE, SOUTH
AFRICA**

by

Raymond Mabaso

has been edited for language and technical aspects.

EM Lemmer



104 Charles St
Brooklyn
Pretoria

Annexure O: Letter from the statistician

To whom it may concern

2012-11 - 15

Hereby I confirm that the following thesis:

**BLINDNESS AND VISUAL IMPAIRMENT AMONG PEOPLE WITH
DIABETES 40 YEARS AND OLDER IN LIMPOPO PROVINCE, SOUTH
AFRICA**

by

Raymond Mabaso

Statistical analysis was done by Prof P Ndlovu and Ms M A Managa.

Department of Statistics

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